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(54) BLOOD PRESSURE MEASURING DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To eliminate a troublesome manipulation at measuring the blood pressure and enhance the easiness in handling the device by arranging it so that the blood pressure is calculated on the basis of the pulsation signal obtained through sensingand thereforeonly one sensora pulsation sensormust be put on the body of a subject.

SOLUTION: A blood pressure measuring device senses the pulsation generated by blood circulation in a human body using a pulsation sensing means 8calculates the feature amount related to the blood pressure using a feature amount calculating means 11 on the basis of the pulsation signal obtained through sensingand calculates the blood pressure using a blood pressure calculating means 18 on the basis of the obtained feature amount. According to this configuration where the blood pressure is determined on the basis of pulsation signalsonly one sensora pulsation sensormust be put on the body of a subject to lead to elimination of troublesomeness in manipulation at measuring the blood pressure and enhancement of the easiness in handling the deviceand further because the blood pressure measurement is conducted through computation of the feature amount related to the blood pressureaccurate measurements can be obtained even with varying shape of pulsation.

CLAIMS

[Claim(s)]

[Claim 1]Blood-pressure-measurement equipment comprising:

A pulse wave detection means to detect a pulse wave produced by blood circulation of a human body.
A characteristic quantity calculating means which calculates characteristic quantity relevant to blood pressure based on a pulse wave signal outputted from said pulse wave detection means.
A blood-pressure calculating means which calculates blood pressure based on a characteristic quantity signal outputted from said characteristic quantity calculating means.

[Claim 2]The blood-pressure-measurement equipment according to claim 1 with a pulse wave amendment part which a pulse wave detection means calculates a pulse wave intervaland amends a pulse wave signal at intervals of said pulse wave.
[Claim 3]Each wave height of a pulse wave signal with which a characteristic quantity calculating means is outputted from a pulse wave detection meansa ratio of each of said wave heightTime from a pulse wave standup point to said each wavesaid time interval between each wavean integral value of a pulse wavethe blood-pressure-measurement equipment according to claim 1 or 2 with pulse wave characteristic quantity operation part which calculates at least one of the pulse rates as pulse wave characteristic quantity.
[Claim 4]Blood-pressure-measurement equipment comprising of Claims 1-3 given in any 1 clause:
Speed pulse wave operation part which calculates a speed pulse wave which is the primary differentiation of a pulse wave based on a pulse wave signal with which a characteristic quantity calculating means is outputted from a pulse wave detection means.
Speed pulse wave characteristic quantity operation part which calculates at least one of each wave height of a speed pulse wave signal outputted from said speed pulse wave operation parta ratio of each of said wave heighttime from said speed pulse wave standup point to said each wavesaid time interval between each waveand the zero cross intervals of said speed pulse wave as speed pulse wave characteristic quantity.

[Claim 5]Blood-pressure-measurement equipment comprising of Claims 1-4 given in any 1 clause:
Acceleration pulse wave operation part which calculates an acceleration pulse wave which is the secondary differentiation of a pulse wave based on a pulse wave signal with which a characteristic quantity calculating means is outputted from a pulse wave detection means.
Acceleration pulse wave characteristic quantity operation part which calculates at least one of each wave height of an acceleration pulse wave signal outputted from said acceleration pulse wave operation parta ratio of each of said wave heightand said the time intervals between each wave as acceleration pulse wave characteristic quantity.

[Claim 6]A pulse wave detection means has two or more pulse wave primary detecting elements which detect a pulse wave of a part by which a human body is differentBlood-pressure-measurement equipment of Claims 1-5 with pulse wave propagation characteristic quantity operation part in which a characteristic quantity calculating means calculates at least one of pulse wave propagation time and the pulse wave velocity as pulse wave propagation characteristic quantity based on a pulse wave signal from said pulse wave primary detecting element given in any 1 clause.
[Claim 7]Blood-pressure-measurement equipment of Claims 1-6 with [a characteristic quantity calculating means makes at least one of height of a human bodyweightsexand the age the amount of physical featuresand] the amount input part of physical features which can be inputted given in any 1 clause.
[Claim 8]Blood-pressure-measurement equipment of Claims 3-7 given in any 1 clause with which a blood-pressure calculating means calculates blood pressure based on at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical features.
[Claim 9]Blood-pressure-measurement equipment of Claims 3-8 which a blood-pressure calculating means has a reference-value input part which can input a reference value of blood pressureand can amend relation between at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featuresand blood pressure to calculate given in any 1 clause.
[Claim 10]Blood-pressure-measurement equipment of Claims 3-9 which a blood pressure value calculating means makes a reference value of blood pressure a teacher signaland learn relation between at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featuresand blood pressure to calculate given in any 1 clause.
[Claim 11]Blood-pressure-measurement equipment of Claims 1-10 which can equip at least one part of the digiti-manus pointan earlobethe digiti-pedis pointthe upper arma wristthe neckand a thorax with a pulse wave detection meansand detect a pulse wave of said part given in any 1 clause.
[Claim 12]The blood-pressure-measurement equipment comprising according to claim 11:
The 1st pulse wave primary detecting element where a pulse wave detection means detects a pulse wave from the digiti-manus point.
The 2nd pulse wave primary detecting element which adjoins the 1st pulse wave primary detecting elementis established and detects a pulse wave from parts other than said fingertip.

[Claim 13]The blood-pressure-measurement equipment according to claim 12 with which the 1st pulse wave primary detecting element and the 2nd pulse wave

primary detecting element have a light-emitting part and a light sensing portion for a photoelectrical pulse wave system to detect a pulse waverespectivelyand both light-emitting parts were shared.
[Claim 14]The blood-pressure-measurement equipment according to claim 12 which consists of a pressure sensor with which the 2nd pulse wave primary detecting element detects pulse pressure.
[Claim 15]The blood-pressure-measurement equipment according to claim 12 which consists of a microphone with which the 2nd pulse wave primary detecting element detects a heartbeat.
[Claim 16]Blood-pressure-measurement equipment of Claims 1-15 with a storage parts store which memorizes blood pressure which calculated a blood pressure value calculating means given in any 1 clause.
[Claim 17]Blood-pressure-measurement equipment of Claims 1-15 with a display which displays blood pressure which calculated a blood pressure value calculating means given in any 1 clause.
[Claim 18]Blood-pressure-measurement equipment of Claims 1-15 with an alarm generating part which generates an alarm when a blood pressure value calculating means deviates from a normal range where calculated blood pressure was set up beforehand given in any 1 clause.
[Claim 19]Blood-pressure-measurement equipment of Claims 1-15 with a terminal area for communication for a blood pressure value calculating means to perform communication with an external medium given in any 1 clause.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]In this inventionit is related with blood-pressure-measurement equipment.
Thereforeit is related with the blood-pressure-measurement equipment of a low restraint which measures blood pressure without using especially a cuff (tourniquet).

[0002]
[Description of the Prior Art]As for this conventional kind of blood-pressure-measurement equipment of the low restraintwhat is indicated to JPH8-140948A was common. As shown in drawing 25this blood-pressure-measurement equipment The heart potential electrodes 1 and 2A heart potential signal. The electrocardio processing means 3the finger tip photoelectric pulse wave sensor 4and pulse wave signal to process. It comprises the pulse wave processing means 5 to processthe secondary differential means 6 which differentiates the secondary pulse wave signalthe calculating means 7 which calculates blood pressure based on the heart potential signalthe pulse wave signaland the secondary differential signal of a pulse

wave by which signal processing was carried outand the displaying means 8 which displays the result of an operation. Each part of a human body is equipped with the heart potential electrodes 1 and 2 and the finger tip photoelectric pulse wave sensor 4 like drawing 25.

[0003]And as shown in drawing 26while calculating the pulse wave propagation time PTTpulse wave interval PIand heart rate HR (=1/PI) from a heart potential waveform and a pattern of pulse wavethe above-mentioned calculating means 7the ratio of the 1st wave height x for Masakata of the secondary differential waveform of a pulse wave to the 1st wave height y of a negative direction -- this being set to blood vessel description parameter TPand in quest of y/x or time lag Tb of the 1st peak for Masakata of a pulse waveand the 2nd peak for Masakatabased on a formula (1)a blood pressure value (highest blood pressure (SYS)lowest blood pressure (DIA)) is calculated -- it was like like.

[0004]

SYS and DIA=c1*HR+c2*PTT+c3*TP+c4 Formula (1)

Howeverc1c2c3and c4 are the constants obtained statisticallyand they differ by SYS and DIArespectively.

[0005]

[Problem to be solved by the invention]Howeverin the above-mentioned conventional blood-pressure-measurement equipmentsince pulse wave propagation time had to be found in order to calculate blood pressurethe human body had to be equipped with the sensor of a large number which detect heart potential and a pulse wave like drawing 25and SUBJECT on use occurred. In order to detect heart potential with accuracy sufficient about especially a heart potential electrodethe conductive paste had to be attached to the human body and it usually had to equip with the electrode pan for heart potential measurementand the operation in the case of blood pressure measurement became complicatedand SUBJECT that it was user-unfriendly occurred.

[0006]further -- as parameter TP -- the ratio of the 1st wave height x for Masakata of the secondary differential waveform of a pulse wave to the 1st wave height y of a negative directionalthough blood pressure is calculated using y/x or time lag Tb of the 1st peak for Masakata of a pulse waveand the 2nd peak for MasakataFor examplesince pulse wave form may have changedfor examplea Masakata-oriented peak may have appeared only in one place when it becomes hypertension and arteriosclerosisTb could not be calculated correctly but SUBJECT that blood pressure did not calculate correctly occurred.

[0007]

[Means for solving problem]In order that this invention may solve an aforementioned problemthe pulse wave which a pulse wave detection means produces by the blood circulation of a human body is detecteda characteristic quantity calculating means calculates the characteristic quantity relevant to blood pressure based on the detected pulse wave signaland a blood-pressure calculating means calculates blood pressure based on the calculated characteristic quantity.

[0008]In order to calculate blood pressure based on the detected pulse wave

signal according to the above-mentioned inventionwhile the complicatedness of the operation of only a pulse wave sensor in the case of blood pressure measurement of the sensor with which a human body is equipped is lost and its user-friendliness improvesIn order to calculate the characteristic quantity relevant to blood pressure and to measure blood pressureeven if pulse wave form changesblood pressure can be measured with sufficient accuracy.

[0009]

[Mode for carrying out the invention]The blood-pressure-measurement equipment concerning Claim 1 of this invention is provided with the following.

A pulse wave detection means to detect the pulse wave produced by the blood circulation of a human body.

The characteristic quantity calculating means which calculates the characteristic quantity relevant to blood pressure based on the pulse wave signal outputted from said pulse wave detection means.

The blood-pressure calculating means which calculates blood pressure based on the characteristic quantity signal outputted from said characteristic quantity calculating means.

[0010]And in order to calculate the characteristic quantity relevant to blood pressure and to calculate blood pressure based on the calculated characteristic quantity from the detected pulse wave signalWhile the complicatedness of the operation of only a pulse wave sensor in the case of blood pressure measurement of the sensor with which a human body is equipped is lostand prolonged ream measurement is also attained and being able to improve user-friendlinessIt has a pulse wave amendment part in which a pulse wave detection means calculates a pulse wave intervaland the blood-pressure-measurement equipment applied to Claim 2 of this invention which can measure blood pressure with sufficient accuracy even if pulse wave form changesin order to calculate the characteristic quantity relevant to blood pressure and to measure blood pressure amends a pulse wave signal at intervals of said pulse wave.

[0011]And since a pulse wave amendment part amends a pulse wave signal at intervals of a pulse waveblood pressure can be measured with sufficient accuracy irrespective of the size of a pulse.

[0012]Each wave height of the pulse wave signal with which a characteristic quantity calculating means is outputted from a pulse wave detection means as for the blood-pressure-measurement equipment concerning Claim 3 of this inventionIt has the ratio of each of said wave heightthe time from a pulse wave standup point to said each wavesaid time interval between each wavean integral value of a pulse waveand the pulse wave characteristic quantity operation part that calculates at least one of the pulse rates as pulse wave characteristic quantity.

[0013]Pulse wave characteristic quantity operation part And each wave height of a pulse wave signalthe ratio of each of said wave heightthe time from a pulse wave standup point to said each waveSince at least one of said time interval between each wavethe integral value of a pulse waveand the pulse rates is calculated as

pulse wave characteristic quantity and a blood-pressure calculating means calculates blood pressure based on pulse wave characteristic quantityeven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.

[0014]The speed pulse wave operation part in which the blood-pressure-measurement equipment concerning Claim 4 of this invention calculates the speed pulse wave which is the primary differentiation of a pulse wave based on the pulse wave signal with which a characteristic quantity calculating means is outputted from a pulse wave detection meansIt has the speed pulse wave characteristic quantity operation part which calculates at least one of each wave height of the speed pulse wave signal outputted from said speed pulse wave operation partthe ratio of each of said wave heightthe time from said speed pulse wave standup point to said each wavesaid time interval between each waveand the zero cross interval [of said speed pulse wave] ** as speed pulse wave characteristic quantity.

[0015]Speed pulse wave operation part calculates the speed pulse wave which is the primary differentiation of a pulse waveand speed pulse wave characteristic quantity operation part And each wave height of a speed pulse wave signalThe ratio of each of said wave heightthe time from said speed pulse wave standup point to said each wavesaid time interval between each waveSince at least one of the zero cross intervals of said speed pulse wave is calculated as speed pulse wave characteristic quantity and a blood-pressure calculating means calculates blood pressure based on speed pulse wave characteristic quantityeven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.

[0016]The acceleration pulse wave operation part in which the blood-pressure-measurement equipment concerning Claim 5 of this invention calculates the acceleration pulse wave which is the secondary differentiation of a pulse wave based on the pulse wave signal with which a characteristic quantity calculating means is outputted from a pulse wave detection meansIt has the acceleration pulse wave characteristic quantity operation part which calculates at least one of each wave height of the acceleration pulse wave signal outputted from said acceleration pulse wave operation partthe ratio of each of said wave heightand said the time intervals between each wave as acceleration pulse wave characteristic quantity.

[0017]And acceleration pulse wave operation part calculates the acceleration pulse wave which is the secondary differentiation of a pulse wave based on the pulse wave signal outputted from a pulse wave detection meansIn order that acceleration pulse wave characteristic quantity operation part may calculate at least one of each wave height of an acceleration pulse wave signalthe ratio of each of said wave heightand said the time intervals between each wave as acceleration pulse wave characteristic quantity and a blood-pressure calculating means may calculate blood pressure based on acceleration pulse wave characteristic quantityEven if it becomes hypertension and arteriosclerosis and

pulse wave form changesblood pressure can be measured with sufficient accuracy.
[0018]The blood-pressure-measurement equipment concerning Claim 6 of this invention has two or more pulse wave primary detecting elements where a pulse wave detection means detects the pulse wave of the part by which a human body is differentA characteristic quantity calculating means has pulse wave propagation time and the pulse wave propagation characteristic quantity operation part which calculates at least one of the pulse wave velocity as pulse wave propagation characteristic quantity based on the pulse wave signal from said pulse wave primary detecting element.
[0019]A pulse wave primary detecting element detects the pulse wave of the part by which a human body is differentand pulse wave propagation characteristic quantity operation part based on a pulse wave signal And pulse wave propagation timeIn order that at least one of the pulse wave velocity may be calculated as pulse wave propagation characteristic quantity and a blood-pressure calculating means may calculate blood pressure based on pulse wave propagation characteristic quantityWhile there is no complicatedness of wearing like a heart potential electrodepulse wave propagation characteristic quantity can be calculated and user-friendliness improveseven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.
[0020]A characteristic quantity calculating means makes at least one of the height of a human bodyweightsexand the age the amount of physical featuresand the blood-pressure-measurement equipment concerning Claim 7 of this invention has the amount input part of physical features which can be inputted.
[0021]And since a blood-pressure calculating means calculates blood pressure based on the amount of physical features inputted into the amount input part of physical featurespracticality can be improvedand also blood pressure can be measured with sufficient accuracy.
[0022]As for the blood-pressure-measurement equipment concerning Claim 8 of this inventiona blood-pressure calculating means calculates blood pressure based on at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical features.
[0023]And since a blood-pressure calculating means calculates blood pressure based on at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featureseven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.
[0024]The blood-pressure-measurement equipment concerning Claim 9 of this invention has a reference-value input part with a blood-pressure calculating means able to input the reference value of blood pressureand can amend the relation between at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse

wave propagation characteristic quantityand the amounts of physical featuresand the blood pressure to calculate.
[0025]And since a relation with the blood pressure calculated with the inputted reference value with at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical features can be amendedFor exampleit can respondeven if there is change of a user's blood circulation moving state by agingbody changemovementposture changeetc. or a user changesand practicality can be improvedand also blood pressure can be measured with sufficient accuracy.
[0026]A blood pressure value calculating means makes the reference value of blood pressure a teacher signaland the blood-pressure-measurement equipment concerning Claim 10 of this invention learns the relation between at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featuresand the blood pressure to calculate.
[0027]And the relation of the characteristic quantity information and the reference-value signal of the blood pressure from a reference-value input part which are acquired from the characteristic quantity signal from a characteristic quantity calculating means is learned gradually on the spotSince it comes to output the blood pressure corresponding to the characteristic quantity information from a characteristic quantity calculating means even when he has no amendment by the input of a reference value eventuallythe accuracy of blood pressure measurement improves.
[0028]A pulse wave detection means can equip at least one part of the digiti-manus pointan earlobethe digiti-pedis pointthe upper arma wristthe neckand a thorax with the blood-pressure-measurement equipment concerning Claim 11 of this inventionand it detects the pulse wave of said part.
[0029]And since a pulse wave is easily detectable by a pulse wave detection means by any partuser-friendliness can be improved.
[0030]The blood-pressure-measurement equipment concerning Claim 12 of this invention is provided with the following.
The 1st pulse wave primary detecting element where a pulse wave detection means detects a pulse wave from the digiti-manus point.
The 2nd pulse wave primary detecting element which adjoins the 1st pulse wave primary detecting elementis established and detects a pulse wave from parts other than said fingertip.

[0031]And since the 1st pulse wave primary detecting element and the 2nd pulse wave primary detecting element adjoina miniaturization can be attained and it is convenient to carry.
[0032]The blood-pressure-measurement equipment concerning Claim 13 of this invention has a light-emitting part and a light sensing portion for the 1st pulse

wave primary detecting element and the 2nd pulse wave primary detecting element to detect a pulse wave by a photoelectrical pulse wave systemrespectivelyand both light-emitting parts are shared.
[0033]And since both light-emitting parts are sharedthey can perform reduction of parts and their practicality is high. The blood-pressure-measurement equipment concerning Claim 14 of this invention consists of a pressure sensor with which the 2nd pulse wave primary detecting element detects pulse pressure.
[0034]And since a pressure pulse wave is detected from the neck or a thorax and a pulse wave can be detected in the position near the heartthe arithmetic precision of pulse wave propagation time and pulse wave velocity can be improved.
[0035]The blood-pressure-measurement equipment concerning Claim 15 of this invention consists of a microphone with which the 2nd pulse wave primary detecting element detects a heartbeat.
[0036]And since the vibration and the heartbeat by the beat of the heart are detectedthe arithmetic precision of pulse wave propagation time and pulse wave velocity can be improved.
[0037]The blood-pressure-measurement equipment concerning Claim 16 of this invention has a storage parts store which memorizes the blood pressure which the blood pressure value calculating means calculated.
[0038]And since it is renewable by a blood-pressure calculating means at any timethe trend of the decision value from the pastetc. understand the memorized valueand it is user-friendly.
[0039]Blood-pressure-measurement equipment concerning Claim 17 of this invention has a display which displays blood pressure which a blood pressure value calculating means calculated.
[0040]And a display of real time and the memorized past data can be displayed at any timeand it is user-friendly.
[0041]Blood-pressure-measurement equipment concerning Claim 18 of this invention has an alarm generating part which generates an alarmwhen blood pressure which a blood pressure value calculating means calculated deviates from a normal range set up beforehand.
[0042]And since an alarm generating part generates an alarm when calculated blood pressure deviates from a normal rangeabnormalities of the body under sleeping and work can be checkedfor exampleand it is useful for health care.
[0043]Blood-pressure-measurement equipment concerning Claim 19 of this invention has a terminal area for communication for a blood pressure value calculating means to perform communication with an external medium.
[0044]And since communication with an external medium is performed via a terminal area for communicationrenewal of intensive health care in an external medium or required information can be performedand user-friendliness can be improved.
[0045]Hereafteran embodiment of this invention is described using Drawings.
(Embodiment 1) Drawing 1 is a block diagram of blood-pressure-measurement equipment of Embodiment 1 of this inventionand drawing 2 is an outline view of the

equipment. This example is a thing in a case of measuring blood pressure in a finger tip part. In drawing 18 is a pulse wave detection means to detect a pulse wave of a finger tip part produced by blood circulation of a human bodyand it has the pulse wave amendment part 10 which amends a pulse wave signal at intervals of a pulse wave while it calculates a pulse wave interval from a pulse wave signal outputted from photoelectricity type the pulse wave primary detecting element 9 and the pulse wave primary detecting element 9. 11 is a characteristic quantity calculating means which calculates characteristic quantity relevant to blood pressure based on a pulse wave signal outputted from the pulse wave detection means 8Pulse wave characteristic quantity from the pulse wave signal itself. The acceleration pulse wave operation part 15 which calculates the speed pulse wave characteristic quantity operation part 14 which calculates speed pulse wave characteristic quantityand an acceleration pulse wave which is the secondary differentiation of a pulse wave signal from the pulse wave characteristic quantity operation part 12 to calculatethe speed pulse wave operation part 13 which calculates a speed pulse wave which is the primary differentiation of a pulse wave signaland a speed pulse waveIt has the acceleration pulse wave characteristic quantity operation part 16 which calculates acceleration pulse wave characteristic quantity from an acceleration pulse waveand the amount input part 17 of physical features which can input the amount of physical features. 18 is a blood-pressure calculating means which calculates blood pressure based on a characteristic quantity signal outputted from the characteristic quantity calculating means 11Pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityBased on at least one of the amounts of physical featuresblood pressure. When it deviates from a normal range where the blood-pressure operation part 19 to calculatethe reference-value input part 20 which can input a reference value of blood pressurethe storage parts store 21 which memorizes calculated blood pressurethe display 22 which displays calculated blood pressureand calculated blood pressure were set up beforehandit has the alarm generating part 23 which generates an alarm.
[0046]In drawing 224 is a main part of blood-pressure-measurement equipment of this exampleand the main part 24 comprises the pulse wave detection means 8 and the signal processing unit 25. The pulse wave detection means 8 and the signal processing unit 25 are being connected by crookedness and the elastic terminal area 26 so that it can respond to a size of a finger when a finger is equipped with a main partcrookedness of a knuckleetc. When 27 measures a digital pulse waveit is an insert portion for inserting a fingertipit has the elastic section 28 which can be expanded and contracted according to thickness of a fingerand it is designed so that even the 1st joint of a finger can insert enough. The insert portion 27 is equipped with the 1st light-emitting part 29 and 1st light sensing portion 30 as the pulse wave primary detecting element 9. When the 1st light-emitting part 29 and 1st light sensing portion 30 measure a photoelectrical plethysmogramthey are using what is generally usedbut. A light emitting diode and

a photo-transistor are usedor a lamp which has preferably the wavelength of 5000-8000 A which is an extinction belt of hemoglobin in the 1st light-emitting part 29 is usedand a phototube element of selenium vulcanization-ized cadmium is used for the 1st light sensing portion 30. The insert portion 27 is good also as foldable composition using the elastic section 28. Although it is the composition that quantity of light which penetrates a fingertip which carried out the right opposite of the 1st light-emitting part 29 and 1st light sensing portion 30and inserted them in the above detects a pulse waveit is good also as composition which detects a reflected light from a fingertip which made the 1st light-emitting part 29 and 1st light sensing portion 30 adjoinand was insertedand detects a pulse wave. The signal processing unit 25 has the characteristic quantity calculating means 11 and the blood-pressure calculating means 18and the amount input part 17 of physical featuresthe reference-value input part 20the display 22and the alarm generating part 23 are installed in the surface. 31 is a terminal area for communication for performing communication with the main part 24 and an external medium. Although a drive of the main part 24 performs a cell built in an inside of a main part as a power supplyit may supply a power supply from the exterior via a terminal of the terminal area 31 for communication.

[0047]Nextoperation and an operation are explained. A fingertip is inserted in the insert portion 27the digiti-manus point is equipped with the main part 24 like drawing 3and measurement of blood pressure is started. Drawing 4 is a flow chart in the case of blood pressure measurement. A pulse wave is first detected by ST1. Herethe pulse wave primary detecting element 9 (the 1st light-emitting part 29the 1st light sensing portion 30) detects a digital pulse wave. The general form of the detected pulse wave is shown in drawing 5 (a) and drawing 6 (b). Drawing 5 (a) is a pattern of pulse wave which is seen by the youth with mainly normal blood pressureand is called a normal catacrotic wave. Drawing 6 (a) is a pattern of pulse wave which is seen by a hypertension person and elderly people and is called an anacrotic wave. Since agitation of a baseline may arise by motion of the body etc.the pulse wave amendment part 10 extracts two or more patterns of pulse wave in every beat from a pulse wave signaland doubles and averages a baselineand the pulse wave signal which the pulse wave primary detecting element 9 detected asks for an average pattern of pulse wave. And based on this waveformthe pulse wave amendment part 10 searches for the pulse wave interval Pi (ST2)and amends the time-axis of the original pattern of pulse wave if needed. (ST3) It is because this needs to amend individual difference about a time factor among the characteristic quantity of the pattern of pulse wave which there is individual difference in a pulse rate and is mentioned later. About a correction formulathe formula of Bazzet (BazzetHC.1920) shown by (several 1) is used.

[0048]

[Mathematical formula 1]

[0049]Nextthe characteristic quantity calculating means 11 calculates

characteristic quantity based on the pulse wave signal from the pulse wave amendment part 10 by ST4. How to calculate characteristic quantity using drawing 5 – drawing 7 is explained. In drawing 5 and drawing 6(b) is calculated by the speed pulse wave operation part 13 by the waveform of the speed pulse wave which differentiated the primary pulse wave. (c) calculates a pulse wave by the acceleration pulse wave operation part 15 by the waveform of the acceleration pulse wave differentiated the 2nd order. In drawing 5 (a) and drawing 6 (a)as for Sa pulse wave risesas for a point and Pthe tidal wave and C call D a notchit is called relaxation Mineand A is called before **** for ******** and T.

[0050]In the pulse wave characteristic quantity operation part 12P is called for as wave-like maximum points. About TCand Dby drawing 5 (a)since it has appeared as a clear peakit can ask as a zero crossing point of a speed pulse wave. When ACand D do not appear as a clear peak like drawing 6 (a)it carries out like drawing 7 and asks for ACand D. Firstabout Afrom a zero crossing point of an acceleration pulse wavethe altitude l1 and l2 are subtracted and the tangent l3 and l4 are subtracted in the intersection p1 of l1l2and a sphygmogramand p2. When subtracting l2 hereand there is no zero crossing point near the point pc of an acceleration pulse wave like drawing 7 (c)l2 is subtracted from pgamma of maximum points. And the altitude l5 is drawn from the intersection p3 of l3 and l4 to a baselineand an intersection of l5 and a sphygmogram is set to A. About Cfrom a zero crossing point of an acceleration pulse wavethe altitude l6 and l7 are subtracted and the tangent l8 and l9 are subtracted in the intersection p4 of l6l7and a sphygmogramand p5. And the altitude l10 is drawn from the intersection p6 of l8 and l9 to a baselineand an intersection of l10 and a sphygmogram is set to C. About Dfrom a zero crossing point of an acceleration pulse wavethe altitude l11 is drawn and the tangent l12 is drawn on the intersection p7 of l11 and a sphygmogram. And the altitude l13 is drawn from the intersection p8 of l9 and l12 to a baselineand an intersection of l13 and a sphygmogram is set to D. Thusalthough it asks for PTCDand Ait may ask using techniquessuch as wave-like pattern recognition. In the pulse wave characteristic quantity operation part 12after asking for PTCDand A as mentioned aboveat least one of each wave height of PTCDand Aa ratio of each of said wave heighttime from a pulse wave standup point to said each wavesaid time interval between each wavean integral value of a pulse waveand the pulse rates is calculated. As shown in drawing 5 (a) and drawing 6 (a)in the case of a normal catacrotic waveas the wave height For examplePamong theseIn the case of alphabetagammadeltaand an anacrotic waveamplitude of APCand D is asked for alphabetagammadeltaand maximum wave quantity for amplitude of TCand D as H (it is alpha and beta in the case of an anacrotic wave in the case of a normal catacrotic wave)respectively. It asks for alpha/beta as a ratio of the wave heightand asks for EI and gamma/H as DI. Tu is calculated as time from a pulse wave standup point to each waveand S-P and S-C are calculated as Terespectively. As a time interval between each wavean integral value to S-P is calculated as an integral value of Tr and a pulse waveand Ispand the pulse rate 60/Pi is calculated for P-C as HR. A pulse wave risesit asks to be

shown in drawing 7 (a) as intersection S' of the tangent l3 and a baselineor the point S is good also as S″ of turning points (the baseline side) of a sphygmogram and the tangent l3. It may ask also about A and C as a turning point (the ******* P side) of a sphygmogram and the tangent l3and a turning point (the baseline side) with the tangent l8respectively.

[0051]In the speed pulse wave characteristic quantity operation part 12at least one of each wave height of the speed pulse wave signal outputted from the speed pulse wave operation part 13the ratio of each of said wave heightthe time from said speed pulse wave standup point to said each wavesaid time interval between each waveand the zero cross intervals of said speed pulse wave is calculated as speed pulse wave characteristic quantity. Among thesefor exampleas shown in drawing 5 (b) and drawing 6 (b)it asks for the maximum wave quantity v of a speed pulse wave as the wave heightand it asks for the period Tu whose speed pulse wave is positive as a time interval between each wave.

[0052]In the acceleration pulse wave characteristic quantity operation part 16at least one of each wave height of the acceleration pulse wave signal outputted from the acceleration pulse wave operation part 15the ratio of each of said wave heightand said the time intervals between each wave is calculated as acceleration pulse wave characteristic quantity. Among thesefor exampleas shown in drawing 5 (c) and drawing 6 (c)it asks for the amplitude aband c of a wave-like maximum point and a minimum pointdand e as the wave height. Hereif each maximum point and a minimum point are above a baselineif abcdand e are below a baselinethey will make a positive value a negative value. b/ac/ad/aand e/a are calculated as a ratio of each wave heightand it is referred to as RbRcRdand Rerespectively.

[0053]It is possible to input at least one of a user's heightweightsexand the age as an amount of physical features if needed from the amount input part 17 of physical features.

[0054]Although the characteristic quantity relevant to [as mentioned above] blood pressure in the characteristic quantity calculating means 11 is calculatedFor exampleit may ask for delta/gamma by a pulse waveor a waveform standing by an acceleration pulse wave and finding the time to the top Rika amplitude c etc. may calculate other indices which were not shown by the aboveor a differential-of-higher-order waveform may be calculated furtherand at least one of the ratio of each wave height and each of said wave height and said each of the wave interval may be calculated as characteristic quantity.

[0055]In ST5the blood-pressure calculating means 18 calculates blood pressure from the judgment line set up beforehand. This judgment line and an operation procedure are explained using drawing 8 - drawing 13. Drawing 8 shows the judgment line L1 in the case of calculating the blood pressure BPusing EI and DI as characteristic quantityand L2. L1 is an object for maximal blood pressureand L2 is an object for the lowest blood pressure here. Blood pressure will tend to become high if EI of EI is small in relation to the elasticity of an arterial canal wall. Blood pressure will tend to become high if DI of DI is large in relation to the caliber of an arterial canali.e.the stress degree of an arterial canal. In the blood-pressure

operation part 19highest-blood-pressure BP1 and lowest-blood-pressure BP2 calculate from EI0 and DI based on drawing 8. Drawing 9 shows the judgment line L3 in the case of calculating the blood pressure BPusing Tu and Te as characteristic quantityand L4. L3 is an object for maximal blood pressureand L4 is an object for the lowest blood pressure here. Blood pressure will tend to become high if Tu of Tu is large in relation to time until an open back center shrinkage force reaches the maximum in an aortic valve. Blood pressure will tend to become high if Te of Te is large in relation to the time which the aortic valve has opened wide. In the blood-pressure operation part 19highest-blood-pressure BP3 and lowest-blood-pressure BP4 calculate from Tu0 and Te based on drawing 9. Drawing 10 shows the judgment line L5 in the case of calculating the blood pressure BPusing Tu0 and v as characteristic quantityand L6. L5 is an object for maximal blood pressureand L6 is an object for the lowest blood pressure here. Blood pressure will tend to become high if Tu of pulse wave velocity is large since the time is also short when blood is smoothly sent [as for Tu] into the tip in addition to the above-mentioned as mentioned above in relation to the size of vascular resistance positive. Blood pressure will tend to become high if v of v is small in relation to the speed to which a pulse wave rises. In the blood-pressure operation part 19highest-blood-pressure BP5 and lowest-blood-pressure BP6 calculate from Tu0 and v based on drawing 10. Drawing 11 shows the judgment line L7 in the case of calculating the blood pressure BPusing Rb and Rd as characteristic quantityand L8. L7 is an object for maximal blood pressureand L8 is an object for the lowest blood pressure here. Blood pressure will tend to become high if the negative value of Rb of Rb is small in relation to the cardiac output of the heart. Blood pressure will tend to become high if the negative value of Rd of Rd is large in relation to the size of the burden of the heart. In the blood-pressure operation part 19highest-blood-pressure BP7 and lowest-blood-pressure BP8 calculate from Rb and Rd based on drawing 11. Drawing 12 shows the judgment line L9 in the case of calculating the blood pressure BPusing EI0 and age as characteristic quantityand L10. L9 is an object for maximal blood pressureand L10 is an object for the lowest blood pressure here. EI is as above-mentionedand blood pressure tends to become high as age becomes high. In the blood-pressure operation part 19highest-blood-pressure BP9 and lowest-blood-pressure BP10 calculate from EI0 and age based on drawing 12. Drawing 13 shows the judgment line L11 in the case of calculating the blood pressure BPusing Tu0 and Rd as characteristic quantityand L12. L11 is an object for maximal blood pressureand L12 is an object for the lowest blood pressure here. It is as [Rd / Tu0 and] above-mentioned. In the blood-pressure operation part 19highest-blood-pressure BP11 and lowest-blood-pressure BP12 calculate from Tu0 and Rd based on drawing 13.

[0056]If the reference value of blood pressure is inputted into the reference-value input part 20amendment of a judgment line will be performed by ST7 ST6. Drawing 14 is explained to an example for the concrete procedure of amendment. It is for drawing 14 amending the judgment line L1 and L2 which calculate the blood

pressure BP based on EI and DI which were shown in drawing 8. In order to explain simplyDI assumes that it is fixing. During EI0' measurementblood-pressure BP1' and BP2' are simultaneously measured with a cuff-type sphygmomanometerand it inputs from the reference-value input part 20 by making these values into a reference value. In ST7the blood-pressure operation part 19 performs amendment of judgment line L1 and L2 based on the inputted reference value. That isif the point p8 and p9 can be found by reference-value EI0'BP1'and BP2' from drawing 14parallel translation of the judgment line L1 and L2 will be carried out so that it may pass along p8 and p9and the newly made judgment line is made into L1' and L2'. Henceforththe blood-pressure operation part 20 calculates EI0 to BP1and BP2 using judgment line L1' and L2'. When there is no input of a reference value ST6the blood-pressure operation part 20 does not amend a judgment line.
[0057]The blood pressure called for by doing in this way in ST8 is memorized to the storage parts store 21and blood pressure is displayed on the display 22 in ST9. It can reproduce at any time and the value memorized by the storage parts store 21 can be displayed on the display 22. When the calculated blood pressure deviates from the normal range set up beforehandthe alarm generating part 23 generates an alarm in ST10 and ST11. It may be made to report generating of an alarm to the 3rd person who is in the place which is distant from a user by a cable or radio. The blood pressure value calculated and memorized can communicate via the terminal area 31 for communication to external mediasuch as an external monitora centralized control devicea personal computerand a cellular phone. It is also possible to perform the input of characteristic quantity or a reference valuea judgment linerenewal of the normal range for an alarm occurrenceetc. via the terminal area 31 for communication from an external medium.
[0058]The result chosen by for examplethe test subject experiment etc. can be processed with a statistical techniqueand the above-mentioned judgment line can search for it. The characteristic quantity at the time of asking for a judgment line is not what is limited to the range of the above-mentioned embodimentIt may ask for a judgment line from at least onesuch as characteristic quantityheightweightsexetc. which are chosen more than from other characteristic quantity calculated by the characteristic quantity calculating means 11for examplealpha-deltaHRPidelta/gammaIspa-eRcReacceleration pulse wave each wave intervaland the 4th differential waveform of a pulse wave. Although blood pressure was calculated from at least two characteristic quantity in the above-mentioned embodimentblood pressure may be calculated from three or more characteristic quantity.
[0059]In this exampleas shown in drawing 2 and drawing 3it was the composition of detecting a pulse wave of a fingertipbut it is good also as composition which detects a photoelectrical pulse wave from an earlobe or the digiti-pedis pointand composition which detects a pressure pulse wave of main arteries from the upper arma wristthe neckand a thorax. In this caseas composition which detects a photoelectrical pulse wavethe 1st light-emitting part 29 and 1st light sensing portion 30 as shown in the above-mentioned embodiment are used according to a

detection part. It is good to use a pressure sensor and an acceleration sensorfor exampleand to use sensorssuch as a desirable flexible polymer piezoelectric sensor of film stateand a strain gageas composition which detects a pressure pulse waveaccording to a detection part.

[0060]In order according to the Embodiment 1 of this invention to calculate characteristic quantity relevant to blood pressure and to calculate blood pressure based on calculated characteristic quantity from a detected pulse wave signalComplicatedness of operation of only a pulse wave sensor in the case of blood pressure measurement of a sensor with which a human body is equipped is lostand in order to calculate characteristic quantity relevant to blood pressure and to measure blood pressureeven if pulse wave form changesit can measure blood pressure with sufficient accuracywhile prolonged ream measurement also becomes possible and can improve user-friendliness.

[0061]Since a pulse wave amendment part amends a pulse wave signal at intervals of a pulse waveblood pressure can be calculated with sufficient accuracy irrespective of the size of a pulse.

[0062]Wave characteristic quantity operation part Each wave height of a pulse wave signalthe ratio of each of said wave heightthe time from a pulse wave standup point to said each waveSince at least one of said time interval between each wavethe integral value of a pulse waveand the pulse rates is calculated as pulse wave characteristic quantity and a blood-pressure calculating means calculates blood pressure based on pulse wave characteristic quantityeven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.

[0063]Speed pulse wave operation part calculates the speed pulse wave which is the primary differentiation of a pulse waveand speed pulse wave characteristic quantity operation part Each wave height of a speed pulse wave signalThe ratio of each of said wave heightthe time from said speed pulse wave standup point to said each wavesaid time interval between each waveSince at least one of the zero cross intervals of said speed pulse wave is calculated as speed pulse wave characteristic quantity and a blood-pressure calculating means calculates blood pressure based on speed pulse wave characteristic quantityeven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.

[0064]Acceleration pulse wave operation part calculates the acceleration pulse wave which is the secondary differentiation of a pulse wave based on the pulse wave signal outputted from a pulse wave detection meansIn order that acceleration pulse wave characteristic quantity operation part may calculate at least one of each wave height of an acceleration pulse wave signalthe ratio of each of said wave heightand said the time intervals between each wave as acceleration pulse wave characteristic quantity and a blood-pressure calculating means may calculate blood pressure based on acceleration pulse wave characteristic quantityEven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.

[0065]Since a blood-pressure calculating means calculates blood pressure based on the amount of physical features inputted into the amount input part of physical featurespracticality can be improvedand also blood pressure can be measured with sufficient accuracy.
[0066]Since a relation with the blood pressure calculated with the inputted reference value with at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantityand the amounts of physical features can be amendedFor exampleit can respondeven if there is change of a user's blood circulation moving state by agingbody changemovementposture changeetc. or a user changesand practicality can be improvedand also blood pressure can be measured with sufficient accuracy.
[0067]It has a storage parts store which memorizes ****** which the blood-pressure calculating means calculatedand since it is renewable by a blood-pressure calculating means at any timethe trend of the decision value from the pastetc. understand the memorized valueand it is user-friendly.
[0068]Since it has a display which displays the blood pressure which the blood pressure value calculating means calculatedthe display of real time and the memorized past data can be displayed at any timeand it is user-friendly.
[0069]Since an alarm generating part generates an alarm when the calculated blood pressure deviates from a normal rangethe abnormalities of the body under sleeping and work can be checkedfor exampleand it is useful for the health care.
[0070]Since it has a terminal area for communication for a blood pressure value calculating means to perform communication with an external medium and communication with an external medium is performedrenewal of the intensive health care in an external medium or required information can be performedand user-friendliness can be improved.
[0071](Embodiment 2) The block diagramdrawing 16and drawing 17 which drawing 15 shows the blood-pressure-measurement equipment of Embodiment 2 of this invention are an outline view of the equipment.
[0072]In this example 2as for a different point from Embodiment 1the pulse wave detection means 8 has two or more pulse wave primary detecting elements 9a-9n which detect the pulse wave of the part by which a human body is differentThe characteristic quantity calculating means 11 based on the pulse wave signal from the pulse wave primary detecting elements 9a-9n Pulse wave propagation timeIt has the pulse wave propagation characteristic quantity operation part 32 which calculates at least one of the pulse wave velocity as pulse wave propagation characteristic quantityWhile the blood-pressure calculating means 18 calculates blood pressure based on at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featuresIt is the point of making the reference value of blood pressure into a teacher signaland learning the relation between at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the

amounts of physical featuresand the blood pressure to calculate. Drawing 16 and drawing 17 are the outline views of the main part 24 in the case of detecting two pulse wavesa fingertip and other parts. Drawing 16 is the figure which looked at the insert portion 27 of Embodiment 1 as came to the upper partand the opposite side is equipped with the 2nd light-emitting part 33 and 2nd light sensing portion 34 in this example with the side which inserts the fingertip of the insert portion 27. The 2nd light-emitting part 33 and 2nd light sensing portion 34 are constituted so that the pulse wave in parts other than a fingertip may be detectedfor examplethey have the same structure as the 1st light-emitting part 29 and the 1st light sensing portion 30. Herein the 1st light-emitting part 29 and 1st light sensing portion 30pulse wave primary detecting element 9a'and the 1st light-emitting part 33 and 2nd light sensing portion 34 become 2nd pulse wave primary detecting element 9b'. [2nd] It is good also as composition which makes the 1st light-emitting part 29 and 2nd light-emitting part 33 serve a double purpose as the same thing. Drawing 17 is the embodiment in which the same place as having equipped with the 1st light-emitting part 29 and 1st light sensing portion 30 by drawing 16 was equipped with the pressure sensor 35 as 2nd pulse wave primary detecting element 9b'. The pressure sensor 35 detects vibration by the beat of the pressure variation (pressure pulse wave) in the skin surface by the pulse in parts other than a fingertipor the heartand comprises the flexible polymer piezoelectric sensor and strain gage of film statefor example. 2nd pulse wave primary detecting element 9b' may consist of microphones which detect a heartbeat.
[0073]The thing of Embodiment 1 and identical codes has the same structureand explanation is omitted. Nextoperation and an operation are explained. A fingertip is inserted in pulse wave primary detecting element 9a' of the insert portion 27while equipping a fingertip with the main part 24 like drawing 18pulse wave primary detecting element 9b' is contacted to any one part of an earlobethe neckand the thoraxand measurement of blood pressure is started. The following advances explanation as a case where an earlobe is made to contact. Since the flow chart in the case of blood pressure measurement is the same as that of drawing 4here explains the detailed level procedure of ST4 and ST5 using drawing 4. If a pulse wave is detected by ST1-ST3 and a pulse wave is amended if neededthe characteristic quantity calculating means 11 will calculate characteristic quantity based on the pulse wave signal from the pulse wave amendment part 10 by ST4. It is as the 1st embodiment having described the operation of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantityand the amount of physical features. Herethe procedure of calculating the pulse wave propagation time and pulse wave velocity as pulse wave propagation characteristic quantity by the pulse wave propagation characteristic quantity operation part 32 using drawing 19 and drawing 20 is explained. Drawing 19 (a) and (b) shows the pulse wave signal detected by the fingertip and the earloberespectively. The pulse wave from an earlobe contacts 2nd pulse wave primary detecting element 9b' of drawing 16 to an earlobeand detects it. From drawing 19each pulse wave rises and pulse wave propagation time

is found as the point S1 and time lag Tc of S2. If a user's heightweightsexageetc. are beforehand inputted from the amount input part 17 of physical featuresBased on the inputted amount of physical featuresthe blood circulation path length from the heart of an earlobe and each fingertip calculates by the pulse wave propagation characteristic quantity operation part 32and the characteristic quantity equivalent to pulse wave velocity is obtained by breaking Tc by the difference of both length.

[0074]In ST5the blood-pressure calculating means 18 calculates blood pressure from the judgment line set up beforehand. Drawing 20 shows the judgment line L13 in the case of calculating the blood pressure BPusing Tu0 and Tc as characteristic quantityand L14. L13 is an object for maximal blood pressureand L14 is an object for the lowest blood pressure here. It is as having mentioned above about Tu0. Blood pressure will tend to become high if Tc of Tc is small in relation to the resistance degree of an arterial canal. In the blood-pressure operation part 19highest-blood-pressure BP13 and lowest-blood-pressure BP14 calculate from Tu0 and Tc based on drawing 20.

[0075]Although the photoelectrical pulse wave was detected from the fingertip and the earlobe using the main part 24 shown in drawing 16 in the above-mentioned embodimentBy contacting 2nd pulse wave primary detecting element 9b' to the neck or a thorax like drawing 18 using the main part 24 shown in drawing 17a photoelectrical pulse wave may be detected from a fingertipa pressure pulse wave may be detected from the neck or a thoraxand pulse wave propagation time and pulse wave velocity may be calculated from a pressure pulse wave and the pulse wave of the digiti-manus point. A microphone may detect a heartbeat as a thing according to a pulse wavepulse wave propagation time and pulse wave velocity may be calculated from the pulse wave of a heartbeat and a fingertipand since both sides can detect a pressure pulse wave and a heartbeat in the position near [earlobe] the heartthe arithmetic precision of pulse wave propagation time and pulse wave velocity improves.

[0076]Nextif the reference value of blood pressure is inputted into the reference-value input part 20amendment of a judgment line will be performed by ST7 ST6. In the same procedure as Embodiment 1input the reference value of blood pressure and In this casepulse wave characteristic quantityAlthough it may be made to amend the relation between at least one of speed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featuresand the blood pressure to calculateHerethe reference value of blood pressure into which the blood pressure value operation part 19 was inputted further is made into a teacher signaland amendment of a judgment line is performed by learning the relation between at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featuresand the blood pressure to calculate. The learning technique which imitated the neuron network is used as a constituent means of the blood pressure value operation part

19 which learns. Input data now The pulse wave characteristic quantity from the characteristic quantity calculating means 11speed pulse wave characteristic quantityAt least one of acceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical features and output data presuppose that it is a blood-pressure signal to the storage parts store 21 and the display 22and I think that a desirable output (namelyteacher signal) is an output signal from the reference-value input part 20. Let a reference value be a value of the blood pressure measured by the cuff-type sphygmomanometer. As a neuron network model meansthere are some which were shown in document 1 (a PDP modela binary name besides D.E. Rumelhartthe Shun'ichi Amari supervision of translation1989)document 2 (seven persons besides the foundation of a neuro computerp102and Kaoru Nakano1990)JP63-55106Betc.
[0077]The multilayer perceptron which was indicated in document 1 and which was known best using the error reverse spreading method as learning algorithm is hereafter taken for an exampleand the composition and operation of a concrete neuron network model means are explained.
[0078]Drawing 21 is a key map of the nerve element used as the constitutional unit of a neuron network model means. The sigmoid function with which 401-40N are false synaptic connection converters which hold the ** type of the nervous synaptic connection in drawing 2140a is an adding machine adding the output from the false synaptic connection converters 401-40Nand 40b sets to h the set-up nonlinear functionfor examplea threshold[0079]
[Mathematical formula 2]

[0080]It is a nonlinear transformation machine which carries out nonlinear transformation of the output of the adding machine 40a to be alike. Since Drawings became complicatedit omittedbut the entrance cable which receives the correcting signal from a correcting means is connected with the false synaptic connection converters 401-40N and the nonlinear transformation machine 40b. The false synaptic connection converters 401-40N serve as a coupling weight coefficient of a neuron network model means. There is operational mode of two kindssignal-processing mode and learning modein this nerve element.
[0081]Hereafteroperation in each mode of a nerve element is explained based on drawing 21. Firstoperation in signal-processing mode is explained. A nerve element takes out one output in response to the N inputs X1-Xn. The i-th input signal Xi is changed into Wi-Xi in the i-th square and shown false synaptic connection converter 40i. It goes into the adding machine 40athe added result y is sent to the nonlinear transformation machine 40band the N signals W1 and X1 changed with the false synaptic connection converters 401-40N - Wn-Xn serve as the final output f (yh). Belowoperation of learning mode is explained. The correcting signal which expresses the correction amounts delta W1-delta Wnand delta h of the conversion parameter from a correcting means with learning mode for the conversion parameters W1-Wnand h of the false synaptic connection converters

401−40N and the nonlinear transformation machine 40b is received[0082]
[Mathematical formula 3]

[0083]It corrects. Drawing 22 is a key map of a signal conversion means which connected the above−mentioned nerve element with 4 paralleland constituted it. The following explanation needless to say does not specify the number of a nerve element which constitutes this signal conversion means as four pieces. In drawing 22511−544 are false synaptic connection convertersand 501−504 are the addition nonlinear transformation machines into which the adding machine 40a explained by drawing 21 and the nonlinear transformation machine 40b were packed. In drawing 22since Drawings became complicated like drawing 21it omittedbut an entrance cable which receives a correcting signal from a correcting means is connected with the false synaptic connection converters 511−544 and the addition nonlinear transformation machines 501−504. The false synaptic connection converters 511−544 also serve as a coupling weight coefficient. About operation of this signal conversion meansoperation of a nerve element explained by drawing 21 stands in a rowand is made.
[0084]Drawing 23 is a block diagram showing the composition of the signal processing means at the time of adopting the error reverse spreading method as learning algorithmand 61 is an above−mentioned signal conversion means. Howeverthe nerve element which receives N inputs here is put in order by M piece parallel. 62 is a correcting means which computes the correction amount of the signal conversion means 61 in learning mode. Hereafterthe operation in the case of learning a signal processing means based on drawing 23 is explained. The signal conversion means 61 receives N input Sin(X)sand outputs M output Sout(X)s. The correcting means 62 receives input signal Sin(X) and output signal Sout(X)and it stands by until there is an input of M error signal deltaj(X)s from the signal conversion means of an error calculating means or the latter part. Error signal deltaj(X) is inputted and it is a correction amount. [0085]
[Mathematical formula 4]

[0086]It calculates and a correcting signal is sent to the signal conversion means 61. The signal conversion means 61 corrects the conversion parameter of an internal nerve element according to the learning mode explained in the top.
[0087]Drawing 24 is a block diagram showing the composition of the multilayer perceptron which used the neuron network model means71X71Yand 71Z are signal conversion means which consist of K piecesL piecesand M nerve elementsrespectively72X72Yand 72Z are correcting meansand 73 is an error calculating means. The operation is explained about the multilayer perceptron constituted as mentioned abovereferring to drawing 24. In the signal processing means 70Xthe signal conversion means 71X receives input Siin(X) (i=1−N)and outputs output Sjout(X) (j=1−K). The correcting means 72X receives signal Siin(X)

and signal Sjout(X)and it stands by until error signal deltaj(X) (j=1-K) is inputted. The same processing as the following is performed in the signal processing means 70Y and 70Zand the signal conversion means 71 Z-twist final output Shout (Z) and (h=1-M) is outputted. The final output Shout (Z) is sent also to the error calculating means 73. In the error calculating means 73an error with the ideal output T (T1.....TM) is calculated by being based on being shown in the valuation function COST following of a square error (formula 5)and error signal deltah (Z) is sent to the correcting means 72Z.
[0088]
[Mathematical formula 5]

[0089]Howevermu is a parameter which defines the learning speed of multilayer perceptron. Nextit is an error signal when a valuation function is made into a square error[0090]
[Mathematical formula 6]

[0091]It becomes. The correcting means 72Z calculates correction amount delta[of the conversion parameter of the signal conversion means 71Z] W (Z) according to the procedure explained in the topThe error signal sent to the correcting means 72Y is calculated based on (the formula 7)correcting signal deltaW (Z) is sent to the signal conversion means 71Zand the error signal delta (Y) is sent to the correcting means 72Y. The signal conversion means 71Z corrects an internal parameter based on correcting signal deltaW (Z). The error signal delta (Y) is given by (the formula 7).
[0092]
[Mathematical formula 7]

[0093]Herewij (Z) is a conversion parameter of the false synaptic connection converter of the signal conversion means 71Z. Hereaftersame processing is performed in the signal processing means 70X and 70Y. By repeating the procedure of the more than called study and performing itmultilayer perceptron will come to take out the output which approximates the ideal output T wellif an input is given. Although three steps of multilayer perceptron were usedhow many steps may this be in the above-mentioned explanation? Although omitted for simplification of explanation about the method of the study improvement in the speed known as an inertial term as it is about the method of correcting conversion parameter h of the nonlinear transformation means in the signal conversion means in document 1this abbreviation does not restrain this invention.
[0094]Thusthe blood-pressure operation part 19 with a neuron network model meansThe pulse wave characteristic quantity from the characteristic quantity calculating means 11speed pulse wave characteristic quantityacceleration pulse

wave characteristic quantityAlso when it is not easy to describe with an easy rule what kind of operation is preferred using the information acquired from characteristic quantity signalssuch as pulse wave propagation characteristic quantity and the amount of physical featuresand the output signal of the reference-value input part 20study can express in a natural form based on the past experience.
[0095]In other wordsthe blood-pressure operation part 19 by learning gradually the relation of the characteristic quantity information and the reference-value signal of the blood pressure from the reference-value input part 20 which are acquired from the characteristic quantity signal from the characteristic quantity calculating means 11 on the spotEven when he has no amendment by the input of a reference value eventuallyit comes to output the blood pressure corresponding to the characteristic quantity information from the characteristic quantity calculating means 11. If the blood pressure which the user newly calculated using the reference-value input part 20 is corrected when the still more nearly same user also changes the posture at the time of measurementother users from whom a form is different use it or it measures during movementthe blood-pressure operation part 19 also follows this by study.
[0096]By the wayas a constituent means of the blood-pressure operation part 19 which learnsa competition pattern classification type vector quantization learning method suitable for the additional study instead of the error reverse spreading method etc. may be used. Not using the learning technique which imitated the neuron networktechniquessuch as a table lookup method based on a suitable ruleartificial intelligencea genetic algorithmmay be used.
[0097]According to the Embodiment 2 of this inventiona pulse wave primary detecting element detects the pulse wave of the part by which a human body is differentIn order that pulse wave propagation characteristic quantity operation part may calculate at least one of pulse wave propagation time and the pulse wave velocity as pulse wave propagation characteristic quantity based on a pulse wave signal and a blood-pressure calculating means may calculate blood pressure based on pulse wave propagation characteristic quantityWhile there is no complicatedness of wearing like a heart potential electrodepulse wave propagation characteristic quantity can be calculated and user-friendliness improveseven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.
[0098]Since a blood-pressure calculating means calculates blood pressure based on at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featureseven if it becomes hypertension and arteriosclerosis and pulse wave form changesblood pressure can be measured with sufficient accuracy.
[0099]A relation of characteristic quantity information and a reference-value signal of blood pressure from a reference-value input part which are acquired from a characteristic quantity signal from a characteristic quantity calculating means is

learned gradually on the spotsince it comes to output blood pressure corresponding to characteristic quantity information from a characteristic quantity calculating means even when he has no amendment by an input of a reference value eventuallyit is effective in accuracy of blood pressure measurement being markedly alikeand improving rather than Embodiment 1.

[0100]Since it has the 2nd pulse wave primary detecting element which a pulse wave detection means adjoins the 1st pulse wave primary detecting element which detects a pulse wave from the digiti-manus pointand the 1st pulse wave primary detecting elementis installedand detects a pulse wave from parts other than said fingertipa miniaturization can be attained and it is convenient to carry.

[0101]The 1st pulse wave primary detecting element and the 2nd pulse wave primary detecting element have a light-emitting part and a light sensing portion for a photoelectrical pulse wave system to detect a pulse waverespectivelysince both light-emitting parts are sharedthey can perform reduction of parts and their practicality is high.

[0102]The 2nd pulse wave primary detecting element consists of a pressure sensor which detects pulse pressureand since it detects a pressure pulse wave from the neck or a thorax and can detect a pulse wave in a position near the heartit can improve arithmetic precision of pulse wave propagation time and pulse wave velocity.

[0103]The 2nd pulse wave primary detecting element is good also as a microphone which detects a heartbeatand since it detects the vibration and the heartbeat by the beat of the heartit can improve the arithmetic precision of pulse wave propagation time and pulse wave velocity.

[0104]While each characteristic quantity calculated as Embodiments 1 and 2 described relates to blood pressureFor exampleEI can also judge the right and wrong of the blood circulation moving state of human bodies other than blood pressure from each characteristic quantityas it said that DI was connected with the caliber of an arterial canali.e.the stress degree of an arterial canalin relation to the elasticity of an arterial canal wall. In this casealthough the blood circulation moving state of a human body may only be judged from each characteristic quantity in a certain timeBased on a time change of each characteristic quantitythe blood circulation moving state of a human body may be judgedfor examplethe blood circulation moving state of a human body may be judged based on the trend of the time series data of each characteristic quantitythe frequency analysis result of time series datathe grade of fluctuationchaos natureetc. If it does in this waywhile calculating blood pressure based on each characteristic quantitythe blood circulation moving state of the human body like the degree of arteriosclerosis can be judgedfor examplea decided result can be displayed simultaneously with blood pressurethe circulatory system of a human body can be evaluated syntheticallyand it is useful for the health care etc.

[0105]

[Effect of the Invention]As explained abovein order that the blood-pressure-measurement equipment concerning Claim 1 of this invention may calculate the

characteristic quantity relevant to blood pressure and may calculate blood pressure based on the calculated characteristic quantity from the detected pulse wave signalWhile the complicatedness of the operation of only a pulse wave sensor in the case of blood pressure measurement of the sensor with which a human body is equipped is lostand prolonged ream measurement is also attained and being able to improve user-friendlinessIn order to calculate the characteristic quantity relevant to blood pressure and to measure blood pressureeven if pulse wave form changesit is effective in the ability to measure blood pressure with sufficient accuracy.

[0106]The blood-pressure-measurement equipment concerning Claim 2 is effective in the ability to measure blood pressure with sufficient accuracy irrespective of the size of a pulsein order that a pulse wave amendment part may amend a pulse wave signal at intervals of a pulse wave.

[0107]Pulse wave characteristic quantity operation part the blood-pressure-measurement equipment concerning Claim 3 Each wave height of a pulse wave signalIn order that at least one of the ratio of each of said wave heightthe time from a pulse wave standup point to said each wavesaid time interval between each wavethe integral value of a pulse waveand the pulse rates may be calculated as pulse wave characteristic quantity and a blood-pressure calculating means may calculate blood pressure based on pulse wave characteristic quantityEven if it becomes hypertension and arteriosclerosis and pulse wave form changesit is effective in the ability to measure blood pressure with sufficient accuracy.

[0108]The blood-pressure-measurement equipment concerning Claim 4 calculates the speed pulse wave whose speed pulse wave operation part is the primary differentiation of a pulse waveSpeed pulse wave characteristic quantity operation part Each wave height of a speed pulse wave signalthe ratio of each of said wave heightthe time from said speed pulse wave standup point to said each waveIn order that at least one of said time interval between each wave and the zero cross intervals of said speed pulse wave may be calculated as speed pulse wave characteristic quantity and a blood-pressure calculating means may calculate blood pressure based on speed pulse wave characteristic quantityeven if it becomes hypertension and arteriosclerosis and pulse wave form changesit is effective in the ability to measure blood pressure with sufficient accuracy.

[0109]The blood-pressure-measurement equipment concerning Claim 5 calculates the acceleration pulse wave which is the secondary differentiation of a pulse wave based on the pulse wave signal with which acceleration pulse wave operation part is outputted from a pulse wave detection meansIn order that acceleration pulse wave characteristic quantity operation part may calculate at least one of each wave height of an acceleration pulse wave signalthe ratio of each of said wave heightand said the time intervals between each wave as acceleration pulse wave characteristic quantity and a blood-pressure calculating means may calculate blood pressure based on acceleration pulse wave characteristic quantityEven if it becomes hypertension and arteriosclerosis and pulse wave form changesit is effective in the ability to measure blood pressure with sufficient accuracy.

[0110]As for the blood-pressure-measurement equipment concerning Claim 6a pulse wave primary detecting element detects the pulse wave of the part by which a human body is differentIn order that pulse wave propagation characteristic quantity operation part may calculate at least one of pulse wave propagation time and the pulse wave velocity as pulse wave propagation characteristic quantity based on a pulse wave signal and a blood-pressure calculating means may calculate blood pressure based on pulse wave propagation characteristic quantityWhile there is no complicatedness of wearing like a heart potential electrodepulse wave propagation characteristic quantity can be calculated and user-friendliness improveseven if it becomes hypertension and arteriosclerosis and pulse wave form changesit is effective in the ability to measure blood pressure with sufficient accuracy.

[0111]Since a blood-pressure calculating means calculates blood pressure based on the amount of physical features inputted into the amount input part of physical featuresthe blood-pressure-measurement equipment concerning Claim 7 can improve practicalityand also it is effective in the ability to measure blood pressure with sufficient accuracy.

[0112]In order thatas for the blood-pressure-measurement equipment concerning Claim 8a blood-pressure calculating means may calculate blood pressure based on at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featuresEven if it becomes hypertension and arteriosclerosis and pulse wave form changesit is effective in the ability to measure blood pressure with sufficient accuracy.

[0113]Since the blood-pressure-measurement equipment concerning Claim 9 can amend a relation with the blood pressure calculated with the inputted reference value with at least one of pulse wave characteristic quantityspeed pulse wave characteristic quantityacceleration pulse wave characteristic quantitypulse wave propagation characteristic quantityand the amounts of physical featuresFor exampleit can respondeven if there is change of a user's blood circulation moving state by agingbody changemovementposture changeetc. or a user changesand practicality can be improvedand also it is effective in the ability to measure blood pressure with sufficient accuracy.

[0114]The blood-pressure-measurement equipment concerning Claim 10 learns gradually the relation of the characteristic quantity information and the reference-value signal of the blood pressure from a reference-value input part which are acquired from the characteristic quantity signal from a characteristic quantity calculating means on the spotSince it comes to output the blood pressure corresponding to the characteristic quantity information from a characteristic quantity calculating means even when he has no amendment by the input of a reference value eventuallyit is effective in the accuracy of blood pressure measurement improving.

[0115]Since a pulse wave detection means can equip at least one part of the digiti-manus pointan earlobethe digiti-pedis pointthe upper arma wristthe neckand

a thorax with the blood-pressure-measurement equipment concerning Claim 11 and a pulse wave can be easily detected by any partit is effective in the ability to improve user-friendliness.
[0116]Since the 1st pulse wave primary detecting element and the 2nd pulse wave primary detecting element adjointhe blood-pressure-measurement equipment concerning Claim 12 can attain a miniaturizationand is effective in being convenient to carry.
[0117]It is effective in the blood-pressure-measurement equipment concerning Claim 13 being able to perform reduction of partsand its practicality being highsince both light-emitting parts are shared.
[0118]It is effective in the ability to improve the arithmetic precision of pulse wave propagation time and pulse wave velocity since the blood-pressure-measurement equipment concerning Claim 14 detects a pressure pulse wave from the neck or a thorax and can detect a pulse wave in the position near the heart from a pressure sensor.
[0119]It is effective in the ability to improve the arithmetic precision of pulse wave propagation time and pulse wave velocity since the blood-pressure-measurement equipment concerning Claim 15 detects the vibration and the heartbeat by the beat of the heart with a microphone.
[0120]Since the value the blood-pressure-measurement equipment concerning Claim 16 was remembered to be is renewable by a blood-pressure calculating means at any timethe trend of the decision value from the pastetc. are known and it is effective in being user-friendly.
[0121]It is effective in the blood-pressure-measurement equipment concerning Claim 17 being able to display the display of real timeand the memorized past data at any timeand being user-friendly.
[0122]Since an alarm generating part generates an alarm when the calculated blood pressure deviates from a normal rangethe blood-pressure-measurement equipment concerning Claim 18 can check the abnormalities of the body under sleeping and workfor exampleand is effective in being useful for the health care.
[0123]It is effective in the ability it to perform renewal of the intensive health care in an external mediumor required informationand improve user-friendliness since the blood-pressure-measurement equipment furthermore applied to Claim 19 performs communication with an external medium via the terminal area for communication.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The block diagram of the blood-pressure-measurement equipment of Embodiment 1 of this invention
[Drawing 2]The outline view of the blood-pressure-measurement equipment
[Drawing 3]The figure showing the mounting parts to the human body of the

blood-pressure-measurement equipment
[Drawing 4]The flow chart which shows the blood-pressure-measurement procedure of the blood-pressure-measurement equipment
[Drawing 5](a) The waveform characteristic figure showing the normal catacrotic wave in the blood-pressure-measurement equipment
(b) The waveform characteristic figure showing the speed pulse wave
(c) The characteristic figure showing the acceleration pulse wave
[Drawing 6](a) The waveform characteristic figure showing the pulse wave of an anacrotic wave
(b) The waveform characteristic figure showing the speed pulse wave
(c) The waveform characteristic figure showing the acceleration pulse wave
[Drawing 7](a) The characteristic figure showing the procedure of calculating the characteristic quantity of the anacrotic wave in the blood-pressure-measurement equipment
(b) The characteristic figure showing the procedure of calculating the characteristic quantity of the anacrotic wave
(c) The characteristic figure showing the procedure of calculating the characteristic quantity of the anacrotic wave
[Drawing 8]The characteristic figure showing the relation between the blood pressure in the blood-pressure-measurement equipmentand EI and DI
[Drawing 9]The characteristic figure showing the relation between the blood pressure in the blood-pressure-measurement equipmentand Tu and Te
[Drawing 10]The characteristic figure showing the relation between the blood pressure in the blood-pressure-measurement equipmentand Tu and v
[Drawing 11]The characteristic figure showing the relation between the blood pressure in the blood-pressure-measurement equipmentand Rb and Rd
[Drawing 12]The characteristic figure showing the relation between the blood pressure in the blood-pressure-measurement equipmentand EI and age
[Drawing 13]The characteristic figure showing the relation between the blood pressure in the blood-pressure-measurement equipmentand Tu and Rd
[Drawing 14]The characteristic figure showing the procedure which amends the judgment line of the blood pressure in the blood-pressure-measurement equipment with a reference value
[Drawing 15]The block diagram of the blood-pressure-measurement equipment in Embodiment 2 of this invention
[Drawing 16]The outline view of the blood-pressure-measurement equipment
[Drawing 17]The outline view of the blood-pressure-measurement equipment
[Drawing 18]The figure showing the mounting parts to the human body of the blood-pressure-measurement equipment
[Drawing 19](a) The characteristic figure showing the procedure of calculating Tc in the blood-pressure-measurement equipment
(b) The characteristic figure showing the procedure of calculating the TC
[Drawing 20]The characteristic figure showing the relation between the blood pressure in the blood-pressure-measurement equipmentand Tu and Tc

[Drawing 21]The key map of the nerve element used as the constitutional unit of the neuron network model means of the blood-pressure-measurement equipment
[Drawing 22]The key map of the signal conversion means which connected the nerve element of the blood-pressure-measurement equipment with 4 paralleland constituted it
[Drawing 23]The block diagram showing the composition of the signal processing means at the time of adopting the error reverse spreading method as learning algorithm of the blood-pressure-measurement equipment
[Drawing 24]The block diagram showing the composition of the multilayer perceptron using the neuron network model means of the blood-pressure-measurement equipment
[Drawing 25]The block diagram of conventional blood-pressure-measurement equipment
[Drawing 26]The characteristic figure showing the procedure of asking for PTT in the blood-pressure-measurement equipment of the formerPITbxand y
[Explanations of letters or numerals]
8 Pulse wave detection means
9 Pulse wave primary detecting element
9a-9n Pulse wave primary detecting element
9a' 1st pulse wave primary detecting element
9b' 2nd pulse wave primary detecting element
10 Pulse wave amendment part
11 Characteristic quantity calculating means
12 Pulse wave characteristic quantity operation part
13 Speed pulse wave operation part
14 Speed pulse wave characteristic quantity operation part
15 Acceleration pulse wave operation part
16 Acceleration pulse wave characteristic quantity operation part
17 The amount input part of physical features
18 A blood-pressure calculating means
20 A reference-value input part
21 A storage parts store
22 A display
23 An alarm generating part
29 The 1st light-emitting part
30 The 1st light sensing portion
31 A terminal area for communication
32 Pulse wave propagation characteristic quantity operation part
33 The 2nd light-emitting part
34 The 2nd light sensing portion
35 A pressure sensor

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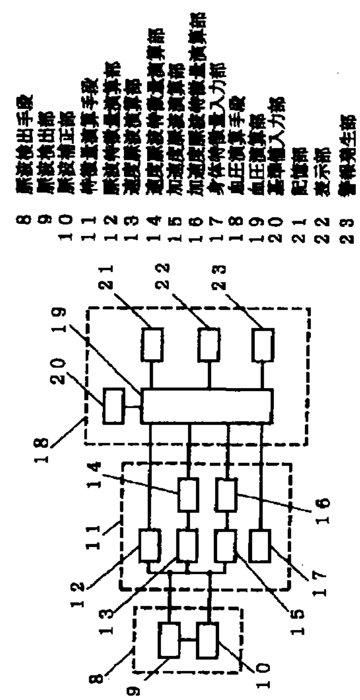
(54)【発明の名称】　血圧測定装置

(57)【要約】

【課題】　本発明は低拘束の血圧測定装置において、血圧測定の際の操作が煩雑となり使い勝手が悪いということ、並びに高血圧や動脈硬化になると脈波形状が変わるので血圧演算に必要なパラメータを正確に求めることができず正しく血圧が演算されないということを課題とするものである。

【解決手段】　本発明は脈波検出手段８が人体の血液循環により生じる脈波を検出し、検出した脈波信号に基づき特徴量演算手段１１が血圧に関連した特徴量を演算し、演算した特徴量に基づき血圧演算手段１８が血圧を演算するものである。従って、検出した脈波信号に基づき血圧を演算するため、人体に装着するセンサは脈波センサのみでよく、血圧測定の際の操作の煩雑さがなくなり使い勝手が向上するとともに、血圧に関連した特徴量を演算して血圧を測定するため脈波形状が変わっても精度よく血圧を測定できるという効果がある。



【特許請求の範囲】

【請求項１】人体の血液循環により生じる脈波を検出する脈波検出手段と、前記脈波検出手段から出力される脈波信号に基づき血圧に関連した特徴量を演算する特徴量演算手段と、前記特徴量演算手段から出力される特徴量信号に基づき血圧を演算する血圧演算手段とからなる血圧測定装置。

【請求項２】脈波検出手段は脈波間隔を演算し、脈波信号を前記脈波間隔で補正する脈波補正部を有した請求項１記載の血圧測定装置。

【請求項３】特徴量演算手段は脈波検出手段から出力される脈波信号の各波高、前記各波高の比、脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、脈波の積分値、脈拍数の少なくとも一つを脈波特徴量として演算する脈波特徴量演算部を有した請求項１または２記載の血圧測定装置。

【請求項４】特徴量演算手段は脈波検出手段から出力される脈波信号に基づき脈波の１次微分である速度脈波を演算する速度脈波演算部と、前記速度脈波演算部から出力される速度脈波信号の各波高、前記各波高の比、前記速度脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、前記速度脈波のゼロクロス間隔の少なくとも一つを速度脈波特徴量として演算する速度脈波特徴量演算部を有した請求項１ないし３のいずれか１項記載の血圧測定装置。

【請求項５】特徴量演算手段は脈波検出手段から出力される脈波信号に基づき脈波の２次微分である加速度脈波を演算する加速度脈波演算部と、前記加速度脈波演算部から出力される加速度脈波信号の各波高、前記各波高の比、前記各波相互の時間間隔の少なくとも一つを加速度脈波特徴量として演算する加速度脈波特徴量演算部を有した請求項１ないし４のいずれか１項記載の血圧測定装置。

【請求項６】脈波検出手段は人体の相異なる部位の脈波を検出する複数の脈波検出部を有し、特徴量演算手段は前記脈波検出部からの脈波信号に基づき脈波伝播時間、脈波伝播速度の少なくとも一つを脈波伝播特徴量として演算する脈波伝播特徴量演算部を有した請求項１ないし５のいずれか１項記載の血圧測定装置。

【請求項７】特徴量演算手段は人体の身長、体重、性別、年齢の少なくとも一つを身体特徴量として入力可能な身体特徴量入力部を有した請求項１ないし６のいずれか１項記載の血圧測定装置。

【請求項８】血圧演算手段は脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つに基づき血圧を演算する請求項３ないし７のいずれか１項記載の血圧測定装置。

【請求項９】血圧演算手段は血圧の基準値を入力することが可能な基準値入力部を有し、脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を補正できる請求項３ないし８のいずれか１項記載の血圧測定装置。

【請求項１０】血圧値演算手段は血圧の基準値を教師信号とし、脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を学習する請求項３ないし９のいずれか１項記載の血圧測定装置。

【請求項１１】脈波検出手段は手の指先、耳朶、足の指先、上腕、手首、頸部、胸部の少なくとも一つの部位に装着可能であり、前記部位の脈波を検出する請求項１ないし１０のいずれか１項記載の血圧測定装置。

【請求項１２】脈波検出手段は手の指先から脈波を検出する第１の脈波検出部と、第１の脈波検出部と隣接して設置され前記指先以外の部位から脈波を検出する第２の脈波検出部とを有する請求項１１記載の血圧測定装置。

【請求項１３】第１の脈波検出部と第２の脈波検出部はそれぞれ光電脈波方式で脈波を検出するための発光部と受光部とを有し、双方の発光部は共有された請求項１２記載の血圧測定装置。

【請求項１４】第２の脈波検出部は脈圧を検出する圧力センサからなる請求項１２記載の血圧測定装置。

【請求項１５】第２の脈波検出部は心音を検出するマイクからなる請求項１２記載の血圧測定装置。

【請求項１６】血圧値演算手段は演算された血圧を記憶する記憶部を有した請求項１ないし１５のいずれか１項記載の血圧測定装置。

【請求項１７】血圧値演算手段は演算された血圧を表示する表示部を有した請求項１ないし１５のいずれか１項記載の血圧測定装置。

【請求項１８】血圧値演算手段は演算された血圧が予め設定された正常範囲を逸脱した場合に警報を発生する警報発生部を有した請求項１ないし１５のいずれか１項記載の血圧測定装置。

【請求項１９】血圧値演算手段は外部媒体との通信を行うための通信用端子部を有した請求項１ないし１５のいずれか１項記載の血圧測定装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、血圧測定装置に関するもので、特にカフ（圧迫帯）を用いないで血圧を測定する低拘束の血圧測定装置に関するものである。

【０００２】

【従来の技術】従来のこの種の低拘束の血圧測定装置は特開平８－１４０９４８号公報に記載されているようなものが一般的であった。この血圧測定装置は図２５に示すように心電位電極１、２、心電位信号を処理する心電処理手段３、指尖光電脈波センサ４、脈波信号を処理する脈波処理手段５、脈波信号を２次微分する２次微分手段６、信号処理された心電位信号と脈波信号と脈波の２

次微分信号に基づき血圧を演算する演算手段７、及び演算結果を表示する表示手段８から構成されている。心電位電極１、２、指尖光電脈波センサ４は図２５のように人体の各部位に装着される。

【０００３】そして図２６に示すように上記演算手段７が、心電位波形と脈波波形から脈波伝播時間ＰＴＴと脈波インターバルＰＩ、心拍数ＨＲ（＝１／ＰＩ）を求めるとともに、脈波の２次微分波形の正方向第１波高ｘと負方向第１波高ｙの比ｙ／ｘまたは脈波の正方向第１ピークと正方向第２ピークの時間差Ｔｂを求めてこれを血管性状パラメータＴＰとし、式（１）に基づき血圧値（最高血圧（ＳＹＳ）、最低血圧（ＤＩＡ））を演算するようにようになっていた。

【０００４】

ＳＹＳ、ＤＩＡ＝ｃ１＊ＨＲ＋ｃ２＊ＰＴＴ＋ｃ３＊ＴＰ＋ｃ４　式（１）

ただし、ｃ１、ｃ２、ｃ３、ｃ４は統計的に得られた定数であり、ＳＹＳとＤＩＡでそれぞれ異なる。

【０００５】

【発明が解決しようとする課題】しかしながら上記従来の血圧測定装置では、血圧を演算するために脈波伝播時間を求めなければならないので、図２５のように心電位と脈波を検出する多数のセンサを人体に装着しなくてはならず、使用上の課題があった。特に心電位電極については精度よく心電位を検出するためには通常、導電性のペーストを人体につけて心電位測定用の電極皿を装着しなくてはならず、血圧測定の際の操作が煩雑となり、使い勝手が悪いという課題があった。

【０００６】さらにパラメータＴＰとして脈波の２次微分波形の正方向第１波高ｘと負方向第１波高ｙの比ｙ／ｘまたは脈波の正方向第１ピークと正方向第２ピークの時間差Ｔｂを用いて血圧を演算しているが、例えば高血圧や動脈硬化になると脈波形状が変わり、例えば正方向のピークが１個所しか現れないことがあるため、Ｔｂを正確に求めることが出来ず正しく血圧が演算されないといった課題があった。

【０００７】

【課題を解決するための手段】本発明は上記課題を解決するため、脈波検出手段が人体の血液循環により生じる脈波を検出し、検出した脈波信号に基づき特徴量演算手段が血圧に関連した特徴量を演算し、演算した特徴量に基づき血圧演算手段が血圧を演算するものである。

【０００８】上記発明によれば、検出した脈波信号に基づき血圧を演算するため、人体に装着するセンサは脈波センサのみでよく、血圧測定の際の操作の煩雑さがなくなり使い勝手が向上するとともに、血圧に関連した特徴量を演算して血圧を測定するため脈波形状が変わっても精度よく血圧を測定できる。

【０００９】

【発明の実施の形態】本発明の請求項１にかかる血圧測定装置は、人体の血液循環により生じる脈波を検出する脈波検出手段と、前記脈波検出手段から出力される脈波信号に基づき血圧に関連した特徴量を演算する特徴量演算手段と、前記特徴量演算手段から出力される特徴量信号に基づき血圧を演算する血圧演算手段とを有する。

【００１０】そして検出した脈波信号から血圧に関連した特徴量を演算し、演算した特徴量に基づき血圧を演算するため、人体に装着するセンサは脈波センサのみでよく、血圧測定の際の操作の煩雑さがなくなり、長時間の連測定も可能となり、使い勝手を向上することができるとともに、血圧に関連した特徴量を演算して血圧を測定するため脈波形状が変わっても精度よく血圧を測定できる本発明の請求項２にかかる血圧測定装置は、脈波検出手段が脈波間隔を演算し、脈波信号を前記脈波間隔で補正する脈波補正部を有する。

【００１１】そして、脈波補正部が脈波信号を脈波間隔で補正するため、脈拍の大小にかかわらず精度よく血圧を測定できる。

【００１２】本発明の請求項３にかかる血圧測定装置は、特徴量演算手段が脈波検出手段から出力される脈波信号の各波高、前記各波高の比、脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、脈波の積分値、脈拍数の少なくとも一つを脈波特徴量として演算する脈波特徴量演算部を有する。

【００１３】そして脈波特徴量演算部が脈波信号の各波高、前記各波高の比、脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、脈波の積分値、脈拍数の少なくとも一つを脈波特徴量として演算し、血圧演算手段が脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００１４】本発明の請求項４にかかる血圧測定装置は、特徴量演算手段が脈波検出手段から出力される脈波信号に基づき脈波の１次微分である速度脈波を演算する速度脈波演算部と、前記速度脈波演算部から出力される速度脈波信号の各波高、前記各波高の比、前記速度脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、前記速度脈波のゼロクロス間隔、の少なくとも一つを速度脈波特徴量として演算する速度脈波特徴量演算部を有する。

【００１５】そして速度脈波演算部が脈波の１次微分である速度脈波を演算し、速度脈波特徴量演算部が速度脈波信号の各波高、前記各波高の比、前記速度脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、前記速度脈波のゼロクロス間隔の少なくとも一つを速度脈波特徴量として演算し、血圧演算手段が速度脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００１６】本発明の請求項５にかかる血圧測定装置は、特徴量演算手段が脈波検出手段から出力される脈波

信号に基づき脈波の２次微分である加速度脈波を演算する加速度脈波演算部と、前記加速度脈波演算部から出力される加速度脈波信号の各波高、前記各波高の比、前記各波相互の時間間隔の少なくとも一つを加速度脈波特徴量として演算する加速度脈波特徴量演算部を有する。

【００１７】そして加速度脈波演算部が脈波検出手段から出力される脈波信号に基づき脈波の２次微分である加速度脈波を演算し、加速度脈波特徴量演算部が加速度脈波信号の各波高、前記各波高の比、前記各波相互の時間間隔の少なくとも一つを加速度脈波特徴量として演算し、血圧演算手段が加速度脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００１８】本発明の請求項６にかかる血圧測定装置は、脈波検出手段が人体の相異なる部位の脈波を検出する複数の脈波検出部を有し、特徴量演算手段が前記脈波検出部からの脈波信号に基づき脈波伝播時間、脈波伝播速度の少なくとも一つを脈波伝播特徴量として演算する脈波伝播特徴量演算部を有する。

【００１９】そして脈波検出部が人体の相異なる部位の脈波を検出し、脈波伝播特徴量演算部が脈波信号に基づき脈波伝播時間、脈波伝播速度の少なくとも一つを脈波伝播特徴量として演算し、血圧演算手段が脈波伝播特徴量に基づき血圧を演算するため、心電位電極のような装着の煩雑さがなく脈波伝播特徴量を演算することができ使い勝手が向上するとともに、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００２０】本発明の請求項７にかかる血圧測定装置は、特徴量演算手段が人体の身長、体重、性別、年齢の少なくとも一つを身体特徴量として入力可能な身体特徴量入力部を有する。

【００２１】そして血圧演算手段が身体特徴量入力部に入力された身体特徴量に基づき血圧を演算するため、実用性を高めることができる上、精度よく血圧を測定できる。

【００２２】本発明の請求項８にかかる血圧測定装置は、血圧演算手段が脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つに基づき血圧を演算する。

【００２３】そして血圧演算手段が脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つに基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００２４】本発明の請求項９にかかる血圧測定装置は、血圧演算手段が血圧の基準値を入力することが可能な基準値入力部を有し、脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を補正できる。

【００２５】そして入力された基準値により脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を補正できるため、例えば加齢や体質変化、運動、体位変化等により使用者の血液循環動態の変化があったり使用者が変わったりしても対応可能で、実用性を高めることができる上、精度よく血圧を測定できる。

【００２６】本発明の請求項１０にかかる血圧測定装置は、血圧値演算手段が血圧の基準値を教師信号とし、脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を学習する。

【００２７】そして特徴量演算手段からの特徴量信号から得られる特徴量情報と基準値入力部からの血圧の基準値信号との関係を現場で徐々に学習し、最終的には基準値の入力による補正なしでも特徴量演算手段からの特徴量情報に対応した血圧を出力するようになるので、血圧測定の精度が向上する。

【００２８】本発明の請求項１１にかかる血圧測定装置は、脈波検出手段が手の指先、耳朶、足の指先、上腕、手首、頸部、胸部の少なくとも一つの部位に装着可能であり、前記部位の脈波を検出する。

【００２９】そしていずれの部位でも脈波検出手段により脈波を容易に検出できるので、使い勝手を向上できる。

【００３０】本発明の請求項１２にかかる血圧測定装置は、脈波検出手段が手の指先から脈波を検出する第１の脈波検出部と、第１の脈波検出部と隣接して設置され前記指先以外の部位から脈波を検出する第２の脈波検出部とを有する。

【００３１】そして第１の脈波検出部と第２の脈波検出部とが隣接しているため、小型化が図れ携帯に便利である。

【００３２】本発明の請求項１３にかかる血圧測定装置は、第１の脈波検出部と第２の脈波検出部がそれぞれ光電脈波方式で脈波を検出するための発光部と受光部とを有し、双方の発光部は共有されたものである。

【００３３】そして双方の発光部は共有されているため、部品の削減ができ実用性が高い。本発明の請求項１４にかかる血圧測定装置は、第２の脈波検出部が脈圧を検出する圧力センサからなる。

【００３４】そして頸部や胸部から圧脈波を検出し心臓に近い位置で脈波を検出できるので脈波伝播時間及び脈波伝播速度の演算精度を向上することができる。

【００３５】本発明の請求項１５にかかる血圧測定装置は、第２の脈波検出部が心音を検出するマイクからなる。

【００３６】そして心臓の鼓動による振動や心音を検出するので脈波伝播時間及び脈波伝播速度の演算精度を向上することができる。

【００３７】本発明の請求項１６にかかる血圧測定装置

は、血圧値演算手段が演算された血圧を記憶する記憶部を有する。

【００３８】そして記憶された値は血圧演算手段によりいつでも再生できるので、過去からの判定値のトレンド等が判り使い勝手がよい。

【００３９】本発明の請求項１７にかかる血圧測定装置は、血圧値演算手段が演算された血圧を表示する表示部を有する。

【００４０】そしてリアルタイムの表示や記憶された過去のデータをいつでも表示することができ使い勝手がよい。

【００４１】本発明の請求項１８にかかる血圧測定装置は、血圧値演算手段が演算された血圧が予め設定された正常範囲を逸脱した場合に警報を発生する警報発生部を有する。

【００４２】そして演算された血圧が正常範囲を逸脱した場合に警報発生部が警報を発生するため、例えば就寝中や作業中の身体の異常をチェックでき健康管理に役立つ。

【００４３】本発明の請求項１９にかかる血圧測定装置は、血圧値演算手段が外部媒体との通信を行うための通信用端子部を有する。

【００４４】そして通信用端子部を介して外部媒体との通信を行うため、外部媒体での集中健康管理や必要情報の更新ができ使い勝手を向上することができる。

【００４５】以下、本発明の実施例について図面を用いて説明する。

（実施例１）図１は本発明の実施例１の血圧測定装置のブロック図、図２は同装置の外観図である。本実施例は指尖部で血圧を測定する場合のものである。図１において、８は人体の血液循環により生じる指尖部の脈波を検出する脈波検出手段で、光電型の脈波検出部９と脈波検出部９から出力される脈波信号から脈波間隔を演算するとともに脈波信号を脈波間隔で補正する脈波補正部１０を有している。１１は脈波検出手段８から出力される脈波信号に基づき血圧に関連した特徴量を演算する特徴量演算手段で、脈波信号そのものから脈波特徴量を演算する脈波特徴量演算部１２、脈波信号の１次微分である速度脈波を演算する速度脈波演算部１３、速度脈波から速度脈波特徴量を演算する速度脈波特徴量演算部１４、脈波信号の２次微分である加速度脈波を演算する加速度脈波演算部１５、加速度脈波から加速度脈波特徴量を演算する加速度脈波特徴量演算部１６、身体特徴量を入力可能な身体特徴量入力部１７を有している。１８は特徴量演算手段１１から出力される特徴量信号に基づき血圧を演算する血圧演算手段で、脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つに基づき血圧を演算する血圧演算部１９、血圧の基準値を入力することが可能な基準値入力部２０、演算された血圧を記憶する記憶部２１、演算された血圧を表示する表示部２２、演算された血圧が予め設定された正常範囲を逸脱した場合に警報を発生する警報発生部２３を有している。

【００４６】図２において、２４は本実施例の血圧測定装置の本体で、本体２４は脈波検出手段８と信号処理ユニット２５とから構成されている。脈波検出手段８と信号処理ユニット２５とは本体を指に装着した時の指の寸法や指関節の屈曲等に対応できるように屈曲および伸縮自在な接続部２６により接続されている。２７は指尖脈波を測定する際に指先を挿入するための挿入部で、指の太さに応じて伸縮可能な伸縮部２８を有し、指の第１関節までが十分挿入できるよう設計されている。挿入部２７には脈波検出部９としての第１の発光部２９と第１の受光部３０が装着されている。第１の発光部２９と第１の受光部３０は光電容積脈波を測定する際に一般的に用いられるものを使用しているが、発光ダイオードとフォトトランジスタを用いたり、好ましくは第１の発光部２９にはヘモグロビンの吸光帯である５０００～８０００オングストロームの波長をもつランプを使用し、第１の受光部３０にはセレン加硫化カドミウムの光電管素子を使用する。挿入部２７は例えば伸縮部２８を使って折りたたみ可能な構成としてもよい。尚、上記では第１の発光部２９と第１の受光部３０とを正対させて、挿入した指先を透過する光の量により脈波を検出する構成であるが、第１の発光部２９と第１の受光部３０とを隣接させて挿入された指先からの反射光を検出して脈波を検出する構成としてもよい。信号処理ユニット２５は特徴量演算手段１１と血圧演算手段１８を有しており、身体特徴量入力部１７、基準値入力部２０、表示部２２、警報発生部２３が表面に設置されている。３１は本体２４と外部媒体との通信を行うための通信用端子部である。本体２４の駆動は本体内部に内蔵してある電池を電源として行うが、通信用端子部３１の端子を介して外部から電源を供給してもよい。

【００４７】次に動作、作用について説明する。指先を挿入部２７に挿入し、図３のように本体２４を手の指先に装着して血圧の測定を開始する。図４は血圧測定の際のフローチャートである。まずＳＴ１で脈波を検出する。ここでは脈波検出部９（第１の発光部２９、第１の受光部３０）が指尖脈波を検出する。検出された脈波の一般的な形状を図５（ａ）および図６（ｂ）に示す。図５（ａ）は主に血圧の正常な若年者に見られ正常後隆波と呼ばれる脈波波形である。図６（ａ）は高血圧者や高齢者に見られ前隆波と呼ばれる脈波波形である。脈波検出部９が検出した脈波信号は身体の動き等により基線の動揺が生じる場合があるため、脈波補正部１０が脈波信号から一拍毎の脈波波形を複数個抽出して基線を合わせて平均し、平均的な脈波波形を求める。そしてこの波形を基に必要に応じて脈波補正部１０が脈波間隔Ｐｉを求め（ＳＴ２）、元の脈波波形の時間軸を補正する。（Ｓ

Ｔ３）これは脈拍数には個人差があり後述する脈波波形の特徴量のうち時間的要素については個人差を補正する必要があるためである。補正式については例えば（数１）で示されるBazzet（Bazzet,H,C.,１９２０年）の式を用いる。

【００４８】

【数１】

$$\text{補正値} = \text{測定値} / \sqrt{Pi}$$

【００４９】次にＳＴ４で特徴量演算手段１１が脈波補正部１０からの脈波信号に基づき特徴量を演算する。図５～図７を用いて特徴量の求め方を説明する。図５、図６において（ｂ）は脈波を１次微分した速度脈波の波形で速度脈波演算部１３で演算される。また（ｃ）は脈波を２次微分した加速度脈波の波形で加速度脈波演算部１５で演算される。図５（ａ）、図６（ａ）において、Ｓは脈波の立ち上り点、Ｐは縮期王峰、Ｔは潮浪波、Ｃは切痕、Ｄは弛緩峰、Ａは前隆点と呼ばれる。

【００５０】脈波特徴量演算部１２において、Ｐは波形の最大点として求められる。Ｔ、Ｃ、Ｄについては図５（ａ）では明確なピークとして現れているため、速度脈波のゼロクロス点として求めることができる。図６（ａ）のようにA、Ｃ、Ｄが明確なピークとして現れない場合は、図７のようにしてA、Ｃ、Ｄを求める。まずAについては加速度脈波のゼロクロス点から垂線ｌ１、ｌ２を引き、ｌ１、ｌ２と脈波曲線との交点ｐ１、ｐ２において接線ｌ３、ｌ４を引く。ここでｌ２を引く際、図７（ｃ）のように加速度脈波の点ｐｃ近傍でゼロクロス点がない場合は極大点ｐγからｌ２を引いている。そしてｌ３、ｌ４の交点ｐ３から基線に垂線ｌ５を引き、ｌ５と脈波曲線との交点をAとする。Ｃについては加速度脈波のゼロクロス点から垂線ｌ６、ｌ７を引き、ｌ６、ｌ７と脈波曲線との交点ｐ４、ｐ５において接線ｌ８、ｌ９を引く。そしてｌ８、ｌ９の交点ｐ６から基線に垂線ｌ１０を引き、ｌ１０と脈波曲線との交点をＣとする。Ｄについては加速度脈波のゼロクロス点から垂線ｌ１１を引き、ｌ１１と脈波曲線との交点ｐ７において接線ｌ１２を引く。そしてｌ９、ｌ１２の交点ｐ８から基線に垂線ｌ１３を引き、ｌ１３と脈波曲線との交点をＤとする。このようにしてＰ、Ｔ、Ｃ、Ｄ、Aを求めるが、波形のパターン認識等の手法を用いて求めても良い。脈波特徴量演算部１２では上記のようにしてＰ、Ｔ、Ｃ、Ｄ、Aを求めた後、Ｐ、Ｔ、Ｃ、Ｄ、Aの各波高、前記各波高の比、脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、脈波の積分値、脈拍数の少なくとも一つを演算する。このうち例えば図５（ａ）、図６（ａ）に示すように波高として正常後隆波の場合はＰ、Ｔ、Ｃ、Ｄの振幅をそれぞれα、β、γ、δ、前隆波の場合はA、Ｐ、Ｃ、Ｄの振幅をそれぞれα、β、γ、δ、最大波高をＨ（正常後隆波の場合はα、前隆波の場合はβ）として求める。波高の比としてα／βをＥＩ、γ／ＨをＤＩとして求める。脈波立上り点から各波までの時間としてＳ～Ｐ、Ｓ～ＣをそれぞれＴｕ、Ｔｅとして求める。各波相互の時間間隔としてＰ～ＣをＴｒ、脈波の積分値としてＳ～Ｐまでの積分値をＩｓｐ、脈拍数６０／ＰｉをＨＲとして求める。尚、脈波の立ち上り点Ｓは図７（ａ）に示すように接線ｌ３と基線との交点Ｓ’として求めたり、脈波曲線と接線ｌ３との分岐点（基線側）Ｓ”としても良い。またA、Ｃについてもそれぞれ脈波曲線と接線ｌ３との分岐点（縮期王峰Ｐ側）、接線ｌ８との分岐点（基線側）として求めてもよい。

【００５１】速度脈波特徴量演算部１２では速度脈波演算部１３から出力される速度脈波信号の各波高、前記各波高の比、前記速度脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、前記速度脈波のゼロクロス間隔の少なくとも一つを速度脈波特徴量として演算する。このうち例えば図５（ｂ）、図６（ｂ）に示すように波高としては速度脈波の最大波高ｖを求め、各波相互の時間間隔としては速度脈波が正である期間Ｔｕを求める。

【００５２】加速度脈波特徴量演算部１６では加速度脈波演算部１５から出力される加速度脈波信号の各波高、前記各波高の比、前記各波相互の時間間隔の少なくとも一つを加速度脈波特徴量として演算する。このうち例えば図５（ｃ）、図６（ｃ）に示すように波高としては波形の極大点及び極小点の振幅ａ、ｂ、ｃ、ｄ、ｅを求める。ここで、ａ、ｂ、ｃ、ｄ、ｅは各極大点、極小点が基線より上であれば正の値を、基線より下であれば負の値とする。各波高の比としてはｂ／ａ、ｃ／ａ、ｄ／ａ、ｅ／ａを演算し、それぞれＲｂ、Ｒｃ、Ｒｄ、Ｒｅとする。

【００５３】身体特徴量入力部１７からは必要に応じて使用者の身長、体重、性別、年齢の少なくとも一つを身体特徴量として入力することが可能である。

【００５４】上記のようにして特徴量演算手段１１は血圧に関連した特徴量を演算するが、例えば脈波でδ／γを求めたり、加速度脈波で波形の立ち上りから振幅ｃまでの時間を求める等、上記で示さなかった他の指標を演算したり、さらに高次微分波形を演算して各波高、前記各波高の比、前記各波間隔の少なくとも一つを特徴量として演算したりしてもよい。

【００５５】ＳＴ５では予め設定した判定ラインから血圧演算手段１８が血圧を演算する。図８～図１３を用いてこの判定ラインと演算手順を説明する。図８は特徴量としてＥＩとＤＩを用いて血圧ＢＰを演算する場合の判定ラインＬ１、Ｌ２を示したものである。ここでＬ１は最大血圧用、Ｌ２は最低血圧用である。ＥＩは動脈管壁の弾性と関連し、ＥＩが小さいと血圧は高くなる傾向にある。ＤＩは動脈管の口径すなわち動脈管の緊張度合い

と関連し、ＤＩが大きいと血圧は高くなる傾向にある。血圧演算部１９では図８に基づきＥＩ０とＤＩから最高血圧ＢＰ１、最低血圧ＢＰ２が演算される。図９は特徴量としてＴｕとＴｅを用いて血圧ＢＰを演算する場合の判定ラインＬ３、Ｌ４を示したものである。ここでＬ３は最大血圧用、Ｌ４は最低血圧用である。Ｔｕは大動脈弁が開放後心収縮力が最大値に達するまでの時間に関連し、Ｔｕが大きいと血圧は高くなる傾向にある。またＴｅは大動脈弁が開放している時間に関連し、Ｔｅが大きいと血圧は高くなる傾向にある。血圧演算部１９では図９に基づきＴｕ０とＴｅから最高血圧ＢＰ３、最低血圧ＢＰ４が演算される。図１０は特徴量としてＴｕ０とｖを用いて血圧ＢＰを演算する場合の判定ラインＬ５、Ｌ６を示したものである。ここでＬ５は最大血圧用、Ｌ６は最低血圧用である。Ｔｕは前述に加え、末梢に血液がスムーズに送り込まれていると脈波速度は正でその時間も短いため、血管抵抗の大きさに関連し、前述のようにＴｕが大きいと血圧は高くなる傾向にある。ｖは脈波の立ち上りの速さに関連し、ｖが小さいと血圧は高くなる傾向にある。血圧演算部１９では図１０に基づきＴｕ０とｖから最高血圧ＢＰ５、最低血圧ＢＰ６が演算される。図１１は特徴量としてＲｂとＲｄを用いて血圧ＢＰを演算する場合の判定ラインＬ７、Ｌ８を示したものである。ここでＬ７は最大血圧用、Ｌ８は最低血圧用である。Ｒｂは心臓の拍出量に関連し、Ｒｂの負の値が小さいと血圧は高くなる傾向にある。Ｒｄは心臓の負担の大きさに関連し、Ｒｄの負の値が大きいと血圧は高くなる傾向にある。血圧演算部１９では図１１に基づきＲｂとＲｄから最高血圧ＢＰ７、最低血圧ＢＰ８が演算される。図１２は特徴量としてＥＩ０と年齢を用いて血圧ＢＰを演算する場合の判定ラインＬ９、Ｌ１０を示したものである。ここでＬ９は最大血圧用、Ｌ１０は最低血圧用である。ＥＩは前述の通りで、年齢が高くなるにつれ血圧は高くなる傾向にある。血圧演算部１９では図１２に基づきＥＩ０と年齢から最高血圧ＢＰ９、最低血圧ＢＰ１０が演算される。図１３は特徴量としてＴｕ０とＲｄを用いて血圧ＢＰを演算する場合の判定ラインＬ１１、Ｌ１２を示したものである。ここでＬ１１は最大血圧用、Ｌ１２は最低血圧用である。Ｔｕ０とＲｄについては前述の通りである。血圧演算部１９では図１３に基づきＴｕ０とＲｄから最高血圧ＢＰ１１、最低血圧ＢＰ１２が演算される。

【００５６】ＳＴ６では基準値入力部２０に血圧の基準値が入力されるとＳＴ７で判定ラインの補正が行われる。補正の具体的手順を図１４を例に説明する。図１４は図８に示したＥＩとＤＩに基づき血圧ＢＰを演算する判定ラインＬ１、Ｌ２を補正するためのものである。尚、説明を簡単にするためにＤＩは固定しているものとする。ＥＩ０′測定中に同時にカフ式の血圧計により血圧ＢＰ１′、ＢＰ２′を測定してこれらの値を基準値として基準値入力部２０から入力する。ＳＴ７では入力された基準値に基づき血圧演算部１９が判定ラインＬ１、Ｌ２の補正を行う。すなわち図１４より基準値ＥＩ０′、ＢＰ１′、ＢＰ２′により点ｐ８、ｐ９が求まるとｐ８、ｐ９を通るよう判定ラインＬ１、Ｌ２を平行移動させ、新たにできた判定ラインをＬ１′、Ｌ２′とする。以降、血圧演算部２０は判定ラインＬ１′、Ｌ２′を用いてＥＩ０からＢＰ１、ＢＰ２を求める。尚、ＳＴ６で基準値の入力がない場合、血圧演算部２０は判定ラインの補正を行わない。

【００５７】ＳＴ８ではこのようにして求められた血圧を記憶部２１に記憶し、ＳＴ９では血圧を表示部２２に表示する。記憶部２１に記憶された値はいつでも再生でき、表示部２２に表示可能である。演算された血圧が予め設定した正常範囲を逸脱した場合にはＳＴ１０およびＳＴ１１で警報発生部２３が警報を発生する。警報の発生は有線または無線で使用者から離れたところに居る第３者に報知するようにしてもよい。演算され記憶された血圧値は通信用端子部３１を介して外部モニタや集中管理装置、パソコン、携帯電話等の外部媒体へ通信することができる。また、外部媒体から通信用端子部３１を介して特徴量や基準値の入力、判定ラインや警報発生のための正常範囲の更新等を行うことも可能である。

【００５８】上記の判定ラインは例えば被験者実験等により選られた結果を統計的な手法により処理して求めることが出来る。また、判定ラインを求める際の特徴量は上記実施例の範囲に限定されるものではなく、特徴量演算手段１１で演算される他の特徴量、例えばα～δ、ＨＲ、Ｐｉ、δ／γ、Ｉｓｐ、ａ～ｅ、Ｒｃ、Ｒｅ、加速度脈波各波間隔、脈波の４次以上の微分波形から選られる特徴量、身長、体重、性別等の少なくとも一つから判定ラインを求めても良い。また、上記実施例では少なくとも２つの特徴量から血圧を演算したが、３つ以上の特徴量から血圧を演算しても良い。

【００５９】また本実施例では図２及び図３に示したように指先の脈波を検出する構成であったが、耳朶や足の指先から光電脈波を検出する構成や、上腕、手首、頚部、胸部から主要動脈の圧脈波を検出する構成としてもよい。この場合、光電脈波を検出する構成としては、上記実施例で示したような第１の発光部２９及び第１の受光部３０を検出部位に応じて用いる。また圧脈波を検出する構成としては、例えば圧力センサや加速度センサを使用し、好ましくはフィルム状の可撓性の高分子圧電センサや歪みゲージ等のセンサを検出部位に応じて用いるとよい。

【００６０】本発明の実施例１によれば、検出した脈波信号から血圧に関連した特徴量を演算し、演算した特徴量に基づき血圧を演算するため、人体に装着するセンサは脈波センサのみでよく、血圧測定の際の操作の煩雑さがなくなり、長時間の連測定も可能となり、使い勝手が

向上することができるとともに、血圧に関連した特徴量を演算して血圧を測定するため脈波形状が変わっても精度よく血圧を測定できる。

【００６１】また、脈波補正部が脈波信号を脈波間隔で補正するため、脈拍の大小にかかわらず精度よく血圧を演算できる。

【００６２】また、波特徴量演算部が脈波信号の各波高、前記各波高の比、脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、脈波の積分値、脈拍数の少なくとも一つを脈波特徴量として演算し、血圧演算手段が脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００６３】また、速度脈波演算部が脈波の１次微分である速度脈波を演算し、速度脈波特徴量演算部が速度脈波信号の各波高、前記各波高の比、前記速度脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、前記速度脈波のゼロクロス間隔の少なくとも一つを速度脈波特徴量として演算し、血圧演算手段が速度脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００６４】また、加速度脈波演算部が脈波検出手段から出力される脈波信号に基づき脈波の２次微分である加速度脈波を演算し、加速度脈波特徴量演算部が加速度脈波信号の各波高、前記各波高の比、前記各波相互の時間間隔の少なくとも一つを加速度脈波特徴量として演算し、血圧演算手段が加速度脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００６５】また、血圧演算手段が身体特徴量入力部に入力された身体特徴量に基づき血圧を演算するため、実用性を高めることができる上、精度よく血圧を測定できる。

【００６６】また、入力された基準値により脈波特徴量、速度脈波特徴量、加速度脈波特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を補正できるため、例えば加齢や体質変化、運動、体位変化等により使用者の血液循環動態の変化があったり使用者が変わったりしても対応可能で、実用性を高めることができる上、精度よく血圧を測定できる。

【００６７】また、血圧演算手段が演算された血圧をを記憶する記憶部を有し、記憶された値は血圧演算手段によりいつでも再生できるので、過去からの判定値のトレンド等が判り使い勝手がよい。

【００６８】また血圧値演算手段が演算された血圧を表示する表示部を有しているため、リアルタイムの表示や記憶された過去のデータをいつでも表示することができ使い勝手がよい。

【００６９】また、演算された血圧が正常範囲を逸脱した場合に警報発生部が警報を発生するため、例えば就寝中や作業中の身体の異常をチェックでき健康管理に役立つ。

【００７０】さらに、血圧値演算手段が外部媒体との通信を行うための通信用端子部を有し、外部媒体との通信を行うため、外部媒体での集中健康管理や必要情報の更新ができ使い勝手を向上することができる。

【００７１】（実施例２）図１５は本発明の実施例２の血圧測定装置を示すブロック図、図１６、図１７は同装置の外観図である。

【００７２】本実施例２において、実施例１と異なる点は脈波検出手段８が人体の相異なる部位の脈波を検出する複数の脈波検出部９ａ～９ｎを有し、特徴量演算手段１１が脈波検出部９ａ～９ｎからの脈波信号に基づき脈波伝播時間、脈波伝播速度の少なくとも一つを脈波伝播特徴量として演算する脈波伝播特徴量演算部３２を有し、血圧演算手段１８が脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つに基づき血圧を演算するとともに、血圧の基準値を教師信号とし、脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を学習する点である。図１６及び図１７は指先と他の部位の２個所の脈波を検出する場合の本体２４の外観図である。図１６は実施例１の挿入部２７を上側にくるようにして見た図で、本実施例では挿入部２７の指先を挿入する側とは反対の側に第２の発光部３３と第２の受光部３４が装着されている。第２の発光部３３と第２の受光部３４は指先以外の部位での脈波を検出するよう構成され、例えば第１の発光部２９及び第１の受光部３０と同じ構造を有している。ここでは第１の発光部２９及び第１の受光部３０が第１の脈波検出部９ａ′、第２の発光部３３と第２の受光部３４が第２の脈波検出部９ｂ′となる。尚、第１の発光部２９と第２の発光部３３とを同一のものとして兼用する構成としてもよい。図１７は図１６で第１の発光部２９及び第１の受光部３０が装着してあるのと同じ場所に第２の脈波検出部９ｂ′としての圧力センサ３５が装着された実施例である。圧力センサ３５は指先以外の部位での脈拍による皮膚表面での圧力変化（圧脈波）や心臓の鼓動による振動を検出するもので、例えばフィルム状の可撓性高分子圧電センサや歪みゲージで構成される。また第２の脈波検出部９ｂ′は心音を検出するマイクで構成してもよい。

【００７３】尚、実施例１と同一符号のものは同一構造を有し、説明は省略する。次に動作、作用を説明する。指先を挿入部２７の脈波検出部９ａ′に挿入し、図１８のように本体２４を指先に装着するとともに、脈波検出部９ｂ′を耳朶、頸部、胸部のいずれか１つの部位に接触させて血圧の測定を開始する。以下は耳朶に接触させた場合として説明を進める。血圧測定の際のフローチャートは図４と同様であるので、ここでは図４を用いてＳ

Ｔ４及びＳＴ５での詳細手順について説明する。ＳＴ１～ＳＴ３で脈波が検出され、必要に応じて脈波が補正されると、ＳＴ４で特徴量演算手段１１が脈波補正部１０からの脈波信号に基づき特徴量を演算する。脈波特徴量、速度脈波特徴量、加速度脈波特徴量、身体特徴量の演算については第１の実施例で述べた通りである。ここでは図１９、図２０を用い脈波伝播特徴量演算部３２で脈波伝播特徴量としての脈波伝播時間及び脈波伝播速度を演算する手順について説明する。図１９（ａ）、（ｂ）はそれぞれ指先と耳朶で検出した脈波信号を示したものである。耳朶からの脈波は図１６の第２の脈波検出部９ｂ′を耳朶に接触させて検出する。図１９より脈波伝播時間はそれぞれの脈波の立ち上り点Ｓ１、Ｓ２の時間差Ｔｃとして求められる。また予め身体特徴量入力部１７から使用者の身長、体重、性別、年齢等が入力されていれば、入力された身体特徴量に基づき脈波伝播特徴量演算部３２で耳朶と指先それぞれの心臓からの血液循環経路の長さが演算され、双方の長さの差でＴｃを割ることにより脈波伝播速度に相当する特徴量が得られる。

【００７４】ＳＴ５では予め設定した判定ラインから血圧演算手段１８が血圧を演算する。図２０は特徴量としてＴｕ０とＴｃを用いて血圧ＢＰを演算する場合の判定ラインＬ１３、Ｌ１４を示したものである。ここでＬ１３は最大血圧用、Ｌ１４は最低血圧用である。Ｔｕ０については前述した通りである。Ｔｃは動脈管の抵抗度合いと関連し、Ｔｃが小さいと血圧は高くなる傾向にある。血圧演算部１９では図２０に基づきＴｕ０とＴｃから最高血圧ＢＰ１３、最低血圧ＢＰ１４が演算される。

【００７５】尚、上記実施例では図１６に示す本体２４を用いて指先と耳朶から光電脈波を検出したが、図１７に示す本体２４を用いて図１８のように第２の脈波検出部９ｂ′を頚部や胸部に接触させることにより、指先からは光電脈波を検出し、頚部や胸部からは圧脈波を検出して、圧脈波と手の指先の脈波から脈波伝播時間や脈波伝播速度を演算してもよい。また脈波に準じるものとしてマイクで心音を検出し、心音と指先の脈波から脈波伝播時間や脈波伝播速度を演算してもよく、双方とも耳朶より心臓に近い位置で圧脈波や心音を検出できるので脈波伝播時間及び脈波伝播速度の演算精度が向上する。

【００７６】次にＳＴ６では基準値入力部２０に血圧の基準値が入力されるとＳＴ７で判定ラインの補正が行われる。この場合、実施例１と同様な手順で血圧の基準値を入力し、脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を補正するようにしてもよいが、ここではさらに血圧値演算部１９が入力された血圧の基準値を教師信号とし、脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を学習することにより判定ラインの補正が行われる。学習を行う血圧値演算部１９の構成手段として、神経回路網を模した学習手法を用いる。今入力データは特徴量演算手段１１からの脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つ、出力データは記憶部２１及び表示部２２への血圧信号であるとし、また望ましい出力（すなわち教師信号）は基準値入力部２０からの出力信号であると考える。基準値はカフ式の血圧計により測定された血圧の値とする。神経回路網模式手段としては、文献１（ＰＤＰモデル、Ｄ．Ｅ．ラメルハート他２名、甘利俊一監訳、１９８９年）、文献２（ニューロコンピュータの基礎、ｐ１０２、中野馨他７名、１９９０年）、特公昭６３－５５１０６などに示されたものがある。

【００７７】以下、文献１に記載された最もよく知られた学習アルゴリズムとして誤差逆伝搬法を用いた多層パーセプトロンを例にとり、具体的な神経回路網模式手段の構成及び動作について説明する。

【００７８】図２１は、神経回路網模式手段の構成単位となる神経素子の概念図である。図２１において、４０１～４０Ｎは神経のシナプス結合を模式する疑似シナプス結合変換器であり、４０ａは疑似シナプス結合変換器４０１～４０Ｎからの出力を加算する加算器であり、４０ｂは設定された非線形関数、たとえば、しきい値をｈとするシグモイド関数、

【００７９】

【数２】

$$f(y,\ h)=1/(1+\exp(-y+h))$$

【００８０】によって加算器４０ａの出力を非線形変換する非線形変換器である。なお、図面が煩雑になるので省略したが、修正手段からの修正信号を受ける入力線が疑似シナプス結合変換器４０１～４０Ｎと非線形変換器４０ｂにつながっている。また、疑似シナプス結合変換器４０１～４０Ｎが神経回路網模式手段の結合重み係数となる。この神経素子には、信号処理モードと学習モードの２つの種類の動作モードがある。

【００８１】以下、図２１に基づいて神経素子のそれぞれのモードの動作について説明する。まず、信号処理モードの動作の説明をする。神経素子はＮ個の入力Ｘ１～Ｘｎを受けて１つの出力を出す。ｉ番目の入力信号Ｘｉは、四角で示されたｉ番目の疑似シナプス結合変換器４０ｉにおいてＷｉ・Ｘｉに変換される。疑似シナプス結合変換器４０１～４０Ｎで変換されたＮ個の信号Ｗ１・Ｘ１～Ｗｎ・Ｘｎは加算器４０ａに入り、加算結果ｙが非線形変換器４０ｂに送られ、最終出力ｆ（ｙ、ｈ）となる。つぎに、学習モードの動作について説明する。学習モードでは、疑似シナプス結合変換器４０１～４０Ｎと非線形変換器４０ｂの変換パラメータＷ１～Ｗｎとｈを、修正手段からの変換パラメータの修正量ΔＷ１～Δ

ＷｎとΔｈを表す修正信号を受けて、

【００８２】

【数３】

$$W_i+\Delta W_i \quad ; \quad i=1,\ 2,\ \cdots,\ N$$
$$h+\Delta h$$

【００８３】と修正する。図２２は上記神経素子を４つ並列につないで構成した信号変換手段の概念図である。いうまでもなく、以下の説明は、この信号変換手段を構成する神経素子の個数を４個に特定するものではない。図２２において、５１１～５４４は疑似シナプス結合変換器であり、５０１～５０４は、図２１で説明した加算器４０ａと非線形変換器４０ｂをまとめた加算非線形変換器である。図２２において、図２１と同様に図面が煩雑になるので省略したが、修正手段からの修正信号を受ける入力線が疑似シナプス結合変換器５１１～５４４と加算非線形変換器５０１～５０４につながっている。疑似シナプス結合変換器５１１～５４４も結合重み係数となる。この信号変換手段の動作については、図２１で説明した神経素子の動作が並列してなされるものである。

【００８４】図２３は、学習アルゴリズムとして誤差逆伝搬法を採用した場合の信号処理手段の構成を示したブロック図で、６１は上述の信号変換手段である。ただし、ここではＮ個の入力を受ける神経素子がＭ個並列に並べられたものである。６２は学習モードにおける信号変換手段６１の修正量を算出する修正手段である。以下、図２３に基づいて信号処理手段の学習を行う場合の動作について説明する。信号変換手段６１はＮ個の入力Ｓin（Ｘ）を受け、Ｍ個の出力Ｓout（Ｘ）を出力する。修正手段６２は、入力信号Ｓin（Ｘ）と出力信号Ｓout（Ｘ）とを受け、誤差計算手段または後段の信号変換手段からのＭ個の誤差信号δｊ（Ｘ）の入力があるまで待機する。誤差信号δｊ（Ｘ）が入力され修正量を

【００８５】

【数４】

$$\Delta W_{ij}=\delta_j(X)\cdot S_{jout}(X)\cdot(1-S_{jout}(X))\cdot S_{iin}(X)$$
$$(i=1\sim N,\ j=1\sim M)$$

【００８６】と計算し、修正信号を信号変換手段６１に送る。信号変換手段６１は、内部の神経素子の変換パラメータを上で説明した学習モードにしたがって修正する。

【００８７】図２４は、神経回路網模式手段を用いた多層パーセプトロンの構成を示すブロック図であり、７１Ｘ、７１Ｙ、７１ＺはそれぞれＫ個、Ｌ個、Ｍ個の神経素子からなる信号変換手段であり、７２Ｘ、７２Ｙ、７２Ｚは修正手段であり、７３は誤差計算手段である。以上のように構成された多層パーセプトロンについて、図２４を参照しながらその動作を説明する。信号処理手段７０Ｘにおいて、信号変換手段７１Ｘは、入力Ｓiin（Ｘ）（ｉ＝１～Ｎ）を受け、出力Ｓjout（Ｘ）（ｊ＝１～Ｋ）を出力する。修正手段７２Ｘは、信号Ｓiin（Ｘ）と信号Ｓjout（Ｘ）を受け、誤差信号δj（Ｘ）（ｊ＝１～Ｋ）が入力されるまで待機する。以下同様の処理が、信号処理手段７０Ｙ、７０Ｚにおいて行われ、信号変換手段７１Ｚより最終出力Ｓhout（Ｚ）（ｈ＝１～Ｍ）が出力される。最終出力Ｓhout（Ｚ）は、誤差計算手段７３にも送られる。誤差計算手段７３においては、２乗誤差の評価関数ＣＯＳＴ下記に示す（式５）に基づいて理想的な出力Ｔ（Ｔ1、・・・・・、ＴM）との誤差が計算され、誤差信号δh（Ｚ）が修正手段７２Ｚに送られる。

【００８８】

【数５】

$$COST=\mu\cdot\sum_{h=1}^{M}(T_h-S_{hout}(Z))^2/2$$

【００８９】ただし、μは多層パーセプトロンの学習速度を定めるパラメータである。つぎに、評価関数を２乗誤差とした場合には誤差信号は、

【００９０】

【数６】

$$\delta_h(Z)=-\mu\cdot(S_{hout}(Z)-T_h)$$

【００９１】となる。修正手段７２Ｚは、上で説明した手続きにしたがって、信号変換手段７１Ｚの変換パラメータの修正量ΔＷ（Ｚ）を計算し、修正手段７２Ｙに送る誤差信号を（式７）に基づき計算し、修正信号ΔＷ（Ｚ）を信号変換手段７１Ｚに送り、誤差信号δ（Ｙ）を修正手段７２Ｙに送る。信号変換手段７１Ｚは、修正信号ΔＷ（Ｚ）に基づいて内部のパラメータを修正する。なお、誤差信号δ（Ｙ）は（式７）で与えられる。

【００９２】

【数７】

$$\delta_j(Y)=\sum_{i=1}^{M}\delta_i(Z)\cdot S_{jout}(Z)\cdot(1-S_{jout}(Z))\cdot w_{ij}(Z)$$

【００９３】ここで、wij（Ｚ）は信号変換手段７１Ｚの疑似シナプス結合変換器の変換パラメータである。以下、同様の処理が信号処理手段７０Ｘ、７０Ｙにおいて行われる。学習と呼ばれる以上の手続きを繰り返し行うことにより、多層パーセプトロンは入力が与えられると理想出力Ｔをよく近似する出力を出すようになる。な

お、上記の説明においては、３段の多層パーセプトロンを用いたが、これは何段であってもよい。また、文献１にある信号変換手段のなかの非線形変換手段の変換パラメータｈの修正法についてと慣性項として知られる学習高速化の方法については、説明の簡略化のため省略したが、この省略は本発明を拘束するものではない。

【００９４】このように神経回路網模式手段を有した血圧演算部１９は、特徴量演算手段１１からの脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量等の特徴量信号及び基準値入力部２０の出力信号から得られる情報を用いてどのような演算が好ましいかということを簡単なルールで記述することが容易でない場合にも、過去の経験を元に学習によって自然な形で表現することができる。

【００９５】言い換えると血圧演算部１９は、特徴量演算手段１１からの特徴量信号から得られる特徴量情報と基準値入力部２０からの血圧の基準値信号との関係を現場で徐々に学習することによって、最終的には基準値の入力による補正なしでも特徴量演算手段１１からの特徴量情報に対応した血圧を出力するようになる。さらに同一の使用者でも測定時の体位が変わったり、体型が違う他の使用者が使用したり、運動中に測定した場合、その使用者が新たに基準値入力部２０を用いて演算された血圧を訂正すれば、血圧演算部１９も学習によりこれに追従するのである。

【００９６】ところで学習を行う血圧演算部１９の構成手段としては、誤差逆伝搬法でなく追加学習に適した競合パターン分類型のベクトル量子化学習法などを用いてもよい。また神経回路網を模した学習手法を用いず、適当なルールに基づいたテーブルルックアップ法や人工知能、遺伝的アルゴリズムなどの手法を用いてもよい。

【００９７】本発明の実施例２によれば、脈波検出部が人体の相異なる部位の脈波を検出し、脈波伝播特徴量演算部が脈波信号に基づき脈波伝播時間、脈波伝播速度の少なくとも一つを脈波伝播特徴量として演算し、血圧演算手段が脈波伝播特徴量に基づき血圧を演算するため、心電位電極のような装着の煩雑さがなく脈波伝播特徴量を演算することができ使い勝手が向上するとともに、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００９８】また、血圧演算手段が脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つに基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できる。

【００９９】また、特徴量演算手段からの特徴量信号から得られる特徴量情報と基準値入力部からの血圧の基準値信号との関係を現場で徐々に学習し、最終的には基準値の入力による補正なしでも特徴量演算手段からの特徴量情報に対応した血圧を出力するようになるので、実施例１よりも血圧測定の精度が格段に向上するといった効果がある。

【０１００】また、脈波検出手段が手の指先から脈波を検出する第１の脈波検出部と、第１の脈波検出部と隣接して設置され前記指先以外の部位から脈波を検出する第２の脈波検出部とを有しているため、小型化が図れ携帯に便利である。

【０１０１】また、第１の脈波検出部と第２の脈波検出部はそれぞれ光電脈波方式で脈波を検出するための発光部と受光部とを有し、双方の発光部は共有されているため、部品の削減ができ実用性が高い。

【０１０２】また、第２の脈波検出部は脈圧を検出する圧力センサからなり、頸部や胸部から圧脈波を検出し心臓に近い位置で脈波を検出できるので脈波伝播時間及び脈波伝播速度の演算精度を向上することができる。

【０１０３】さらに、第２の脈波検出部は心音を検出するマイクとしてもよく、心臓の鼓動による振動や心音を検出するので脈波伝播時間及び脈波伝播速度の演算精度を向上することができる。

【０１０４】尚、実施例１及び２で述べたように演算された各々の特徴量は血圧に関連したものであるとともに、例えばＥＩは動脈管壁の弾性と関連し、ＤＩは動脈管の口径すなわち動脈管の緊張度合いと関連するといったように、各々の特徴量から血圧以外の人体の血液循環動態の善し悪しを判定することもできる。この場合、単にある時点での各々の特徴量から人体の血液循環動態を判定してもよいが、各々の特徴量の時間的変動に基づいて人体の血液循環動態を判定してもよく、例えば各々の特徴量の時系列データのトレンド、時系列データの周波数分析結果、ゆらぎの程度、カオス性等に基づき人体の血液循環動態を判定してもよい。このようにすれば、各々の特徴量に基づき血圧を演算するとともに、例えば動脈硬化度といったような人体の血液循環動態を判定し、判定結果を血圧と同時に表示することができ、人体の循環系を総合的に評価することができ健康管理等に役立つ。

【０１０５】

【発明の効果】以上説明したように本発明の請求項１にかかる血圧測定装置は検出した脈波信号から血圧に関連した特徴量を演算し、演算した特徴量に基づき血圧を演算するため、人体に装着するセンサは脈波センサのみでよく、血圧測定の際の操作の煩雑さがなくなり、長時間の連測定も可能となり、使い勝手を向上することができるとともに、血圧に関連した特徴量を演算して血圧を測定するため脈波形状が変わっても精度よく血圧を測定できるという効果がある。

【０１０６】また、請求項２にかかる血圧測定装置は脈波補正部が脈波信号を脈波間隔で補正するため、脈拍の大小にかかわらず精度よく血圧を測定できるという効果がある。

【０１０７】また、請求項３にかかる血圧測定装置は脈波特徴量演算部が脈波信号の各波高、前記各波高の比、脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、脈波の積分値、脈拍数の少なくとも一つを脈波特徴量として演算し、血圧演算手段が脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できるという効果がある。

【０１０８】また、請求項４にかかる血圧測定装置は速度脈波演算部が脈波の１次微分である速度脈波を演算し、速度脈波特徴量演算部が速度脈波信号の各波高、前記各波高の比、前記速度脈波立上り点から前記各波までの時間、前記各波相互の時間間隔、前記速度脈波のゼロクロス間隔の少なくとも一つを速度脈波特徴量として演算し、血圧演算手段が速度脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できるという効果がある。

【０１０９】また請求項５にかかる血圧測定装置は加速度脈波演算部が脈波検出手段から出力される脈波信号に基づき脈波の２次微分である加速度脈波を演算し、加速度脈波特徴量演算部が加速度脈波信号の各波高、前記各波高の比、前記各波相互の時間間隔の少なくとも一つを加速度脈波特徴量として演算し、血圧演算手段が加速度脈波特徴量に基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できるという効果がある。

【０１１０】また請求項６にかかる血圧測定装置は脈波検出部が人体の相異なる部位の脈波を検出し、脈波伝播特徴量演算部が脈波信号に基づき脈波伝播時間、脈波伝播速度の少なくとも一つを脈波伝播特徴量として演算し、血圧演算手段が脈波伝播特徴量に基づき血圧を演算するため、心電位電極のような装着の煩雑さがなく脈波伝播特徴量を演算することができ使い勝手が向上するとともに、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できるという効果がある。

【０１１１】また請求項７にかかる血圧測定装置は血圧演算手段が身体特徴量入力部に入力された身体特徴量に基づき血圧を演算するため、実用性を高めることができる上、精度よく血圧を測定できるという効果がある。

【０１１２】また請求項８にかかる血圧測定装置は血圧演算手段が脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つに基づき血圧を演算するため、高血圧や動脈硬化になって脈波形状が変わっても精度よく血圧を測定できるという効果がある。

【０１１３】また請求項９にかかる血圧測定装置は入力された基準値により脈波特徴量、速度脈波特徴量、加速度脈波特徴量、脈波伝播特徴量、身体特徴量の少なくとも一つと演算する血圧との関係を補正できるため、例えば加齢や体質変化、運動、体位変化等により使用者の血液循環動態の変化があったり使用者が変わったりしても対応可能で、実用性を高めることができる上、精度よく血圧を測定できるという効果がある。

【０１１４】また請求項１０にかかる血圧測定装置は特徴量演算手段からの特徴量信号から得られる特徴量情報と基準値入力部からの血圧の基準値信号との関係を現場で徐々に学習し、最終的には基準値の入力による補正なしでも特徴量演算手段からの特徴量情報に対応した血圧を出力するようになるので、血圧測定の精度が向上するという効果がある。

【０１１５】また請求項１１にかかる血圧測定装置は脈波検出手段が手の指先、耳朶、足の指先、上腕、手首、頚部、胸部の少なくとも一つの部位に装着可能であり、いずれの部位でも脈波を容易に検出できるので、使い勝手を向上できるという効果がある。

【０１１６】また請求項１２にかかる血圧測定装置は第１の脈波検出部と第２の脈波検出部とが隣接しているため、小型化が図れ携帯に便利であるという効果がある。

【０１１７】また請求項１３にかかる血圧測定装置は双方の発光部が共有されているため、部品の削減ができ実用性が高いという効果がある。

【０１１８】また請求項１４にかかる血圧測定装置は圧力センサより頚部や胸部から圧脈波を検出し心臓に近い位置で脈波を検出できるので脈波伝播時間及び脈波伝播速度の演算精度を向上することができるという効果がある。

【０１１９】また請求項１５にかかる血圧測定装置はマイクにより心臓の鼓動による振動や心音を検出するので脈波伝播時間及び脈波伝播速度の演算精度を向上することができるという効果がある。

【０１２０】また請求項１６にかかる血圧測定装置は記憶された値は血圧演算手段によりいつでも再生できるので、過去からの判定値のトレンド等が判り使い勝手がよいという効果がある。

【０１２１】また請求項１７にかかる血圧測定装置はリアルタイムの表示や記憶された過去のデータをいつでも表示することができ使い勝手がよいという効果がある。

【０１２２】また請求項１８にかかる血圧測定装置は演算された血圧が正常範囲を逸脱した場合に警報発生部が警報を発生するため、例えば就寝中や作業中の身体の異常をチェックでき健康管理に役立つという効果がある。

【０１２３】さらに請求項１９にかかる血圧測定装置は通信用端子部を介して外部媒体との通信を行うため、外部媒体での集中健康管理や必要情報の更新ができ使い勝手を向上することができるという効果がある。

【図面の簡単な説明】

【図１】本発明の実施例１の血圧測定装置のブロック図

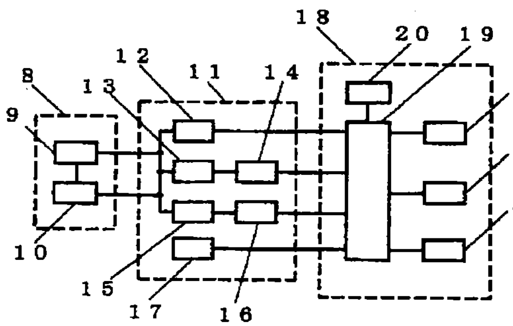
【図２】同血圧測定装置の外観図

【図３】同血圧測定装置の人体への装着部位を示した図

【図４】同血圧測定装置の血圧測定手順を示すフローチ

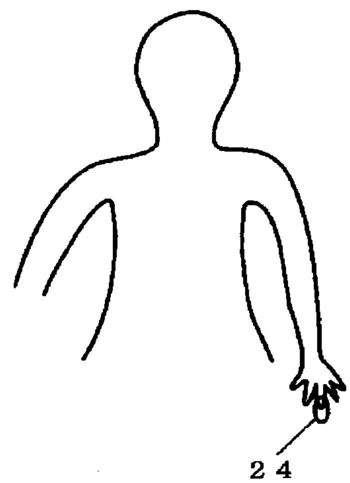
ャート
【図５】（ａ）同血圧測定装置における正常後隆波を示す波形特性図
（ｂ）同速度脈波を示す波形特性図
（ｃ）同加速度脈波を示す特性図
【図６】（ａ）前隆波の脈波を示す波形特性図
（ｂ）同速度脈波を示す波形特性図
（ｃ）同加速度脈波を示す波形特性図
【図７】（ａ）同血圧測定装置における前隆波の特徴量を求める手順を示す特性図
（ｂ）同前隆波の特徴量を求める手順を示す特性図
（ｃ）同前隆波の特徴量を求める手順を示す特性図
【図８】同血圧測定装置における血圧とＥＩ、ＤＩとの関係を示す特性図
【図９】同血圧測定装置における血圧とＴｕ、Ｔｅとの関係を示す特性図
【図１０】同血圧測定装置における血圧とＴｕ、ｖとの関係を示す特性図
【図１１】同血圧測定装置における血圧とＲｂ、Ｒｄとの関係を示す特性図
【図１２】同血圧測定装置における血圧とＥＩ、年齢との関係を示す特性図
【図１３】同血圧測定装置における血圧とＴｕ、Ｒｄとの関係を示す特性図
【図１４】同血圧測定装置における血圧の判定ラインを基準値で補正する手順を示す特性図
【図１５】本発明の実施例２における血圧測定装置のブロック図
【図１６】同血圧測定装置の外観図
【図１７】同血圧測定装置の外観図
【図１８】同血圧測定装置の人体への装着部位を示した図
【図１９】（ａ）同血圧測定装置におけるＴｃを求める手順を示す特性図
（ｂ）同ＴＣを求める手順を示す特性図
【図２０】同血圧測定装置における血圧とＴｕ、Ｔｃとの関係を示す特性図
【図２１】同血圧測定装置の神経回路網模式手段の構成単位となる神経素子の概念図
【図２２】同血圧測定装置の神経素子を４つ並列につないで構成した信号変換手段の概念図
【図２３】同血圧測定装置の学習アルゴリズムとして誤差逆伝搬法を採用した場合の信号処理手段の構成を示すブロック図
【図２４】同血圧測定装置の神経回路網模式手段を用いた多層パーセプトロンの構成を示すブロック図
【図２５】従来の血圧測定装置のブロック図
【図２６】同従来の血圧測定装置におけるＰＴＴ、ＰＩ、Ｔｂ、ｘ、ｙを求める手順を示す特性図
【符号の説明】
８　脈波検出手段
９　脈波検出部
９ａ～９ｎ　脈波検出部
９ａ′　第１の脈波検出部
９ｂ′　第２の脈波検出部
１０　脈波補正部
１１　特徴量演算手段
１２　脈波特徴量演算部
１３　速度脈波演算部
１４　速度脈波特徴量演算部
１５　加速度脈波演算部
１６　加速度脈波特徴量演算部
１７　身体特徴量入力部
１８　血圧演算手段
２０　基準値入力部
２１　記憶部
２２　表示部
２３　警報発生部
２９　第１の発光部
３０　第１の受光部
３１　通信用端子部
３２　脈波伝播特徴量演算部
３３　第２の発光部
３４　第２の受光部
３５　圧力センサ

【図１】

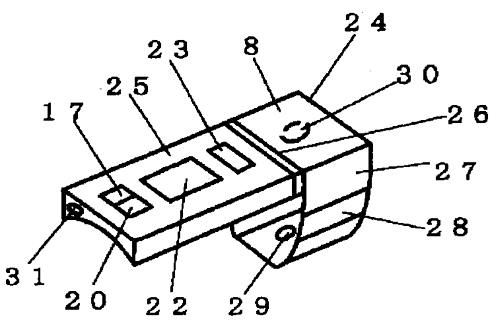


８　脈波検出手段
９　脈波検出部
１０　脈波補正部
１１　特徴量演算手段
１２　脈波特徴量演算部
１３　速度脈波演算部
１４　速度脈波特徴量演算部
１５　加速度脈波演算部
１６　加速度脈波特徴量演算部
１７　身体特徴量入力部
１８　血圧演算手段
１９　血圧演算部
２０　基準値入力部
２１　記憶部
２２　表示部
２３　警報発生部

【図３】

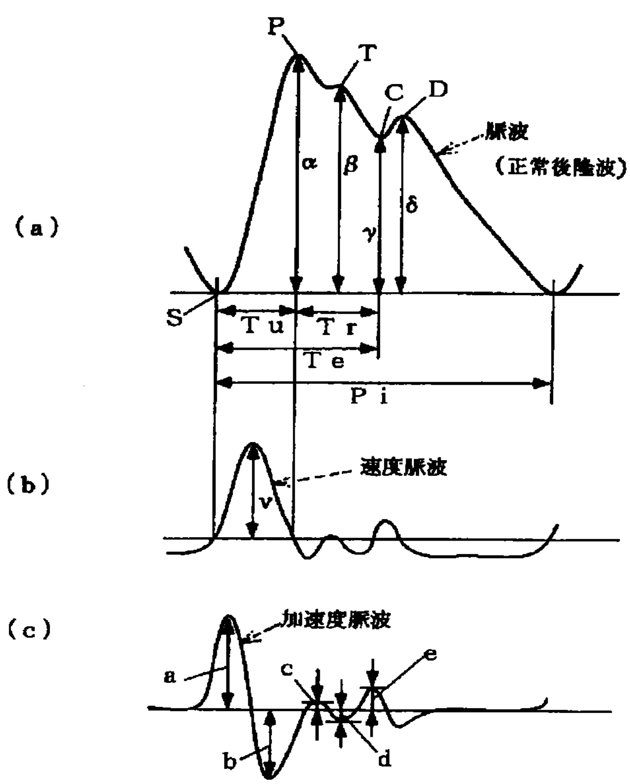


【図２】

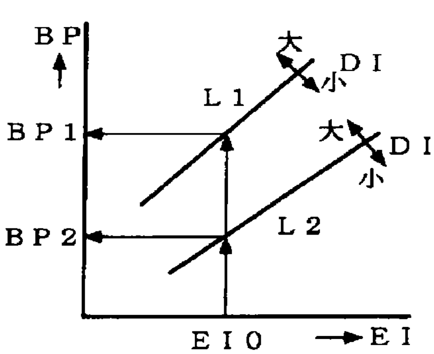


２４　本体
２５　信号処理ユニット
２６　接続部
２７　挿入部
２８　伸縮部
２９　第１の発光部
３０　第１の受光部
３１　通信用端子部

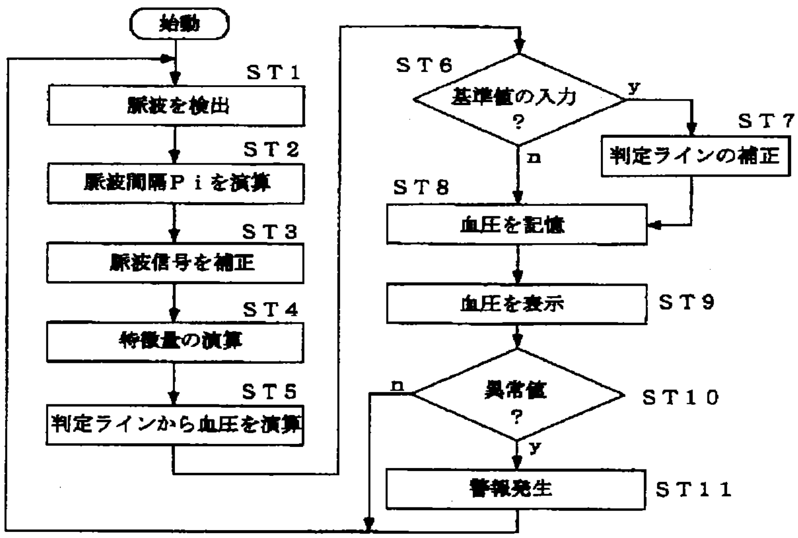
【図５】



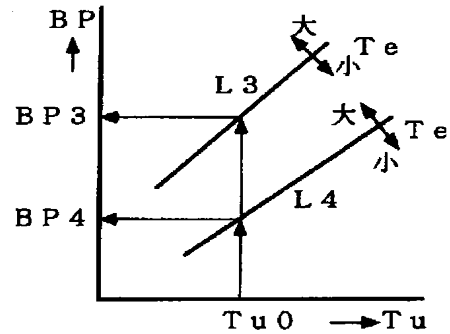
【図８】



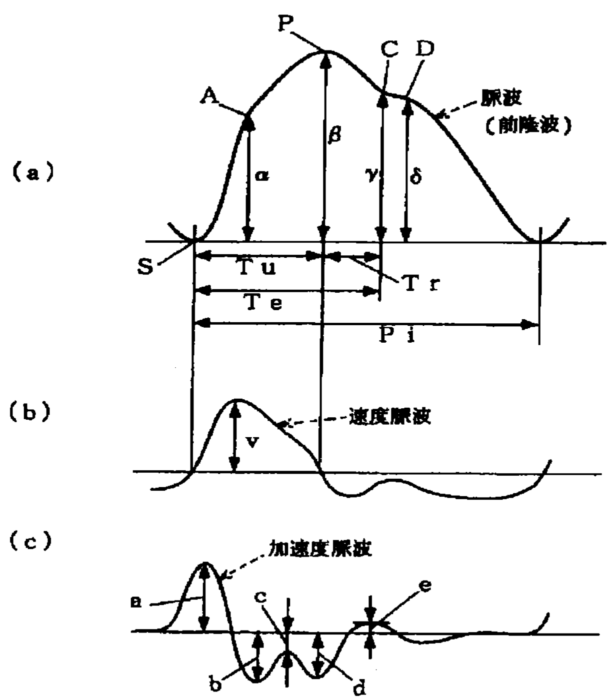
【図4】


始動
ST1
脈波を検出
ST2
脈波間隔Ｐｉを演算
ST3
脈波信号を補正
ST4
特徴量の演算
ST5
判定ラインから血圧を演算
ST6
基準値の入力？
y
n
ST7
判定ラインの補正
ST8
血圧を記憶
血圧を表示
ST9
異常値？
ST10
警報発生
ST11

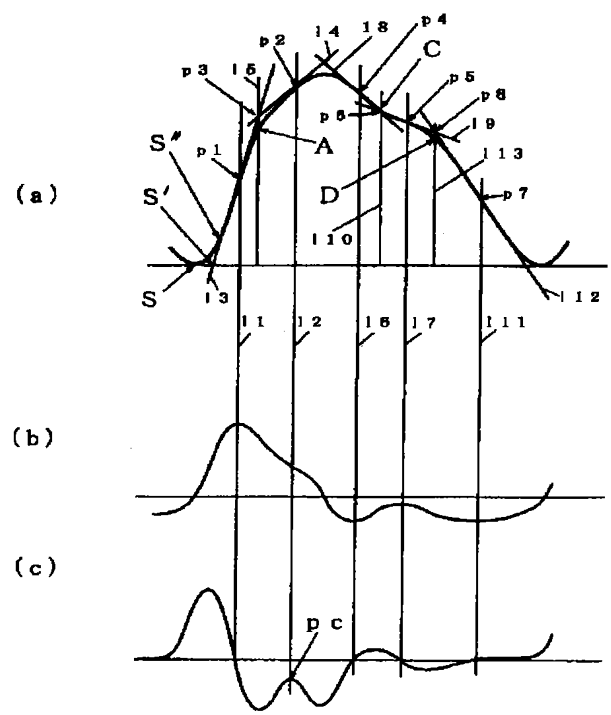
【図9】


BP
BP3
BP4
L3
L4
大
小
Te
Tu0
Tu

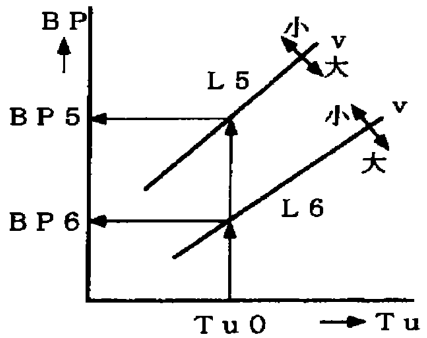
【図6】


(a)
(b)
(c)
P
A
C D
脈波
(前進波)
S
Tu
Tr
Te
Pi
速度脈波
v
加速度脈波
a
b
c
d
e

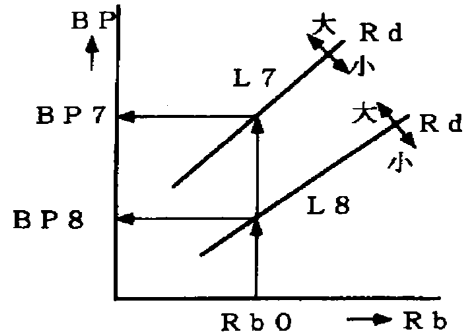
【図7】


(a)
(b)
(c)
C
A
D
S″
S′
S
pc

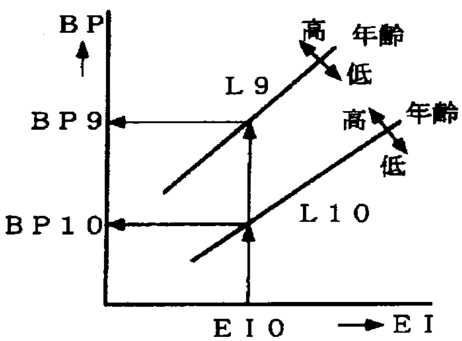
【図１０】



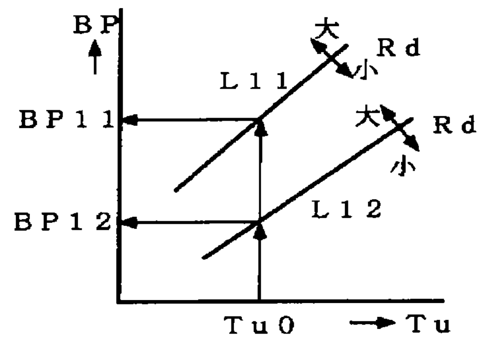
【図１１】



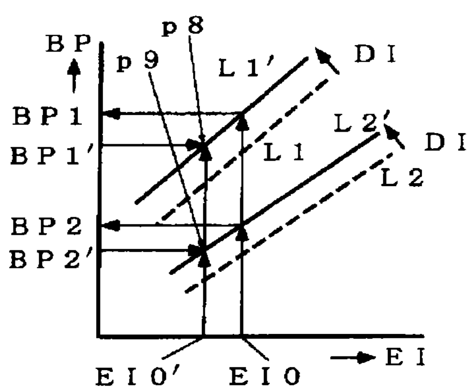
【図１２】



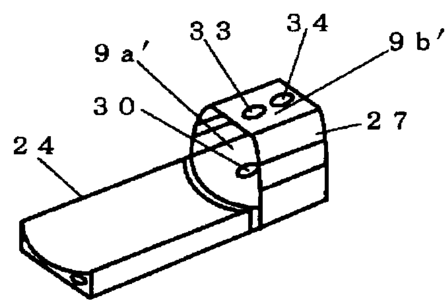
【図１３】



【図１４】



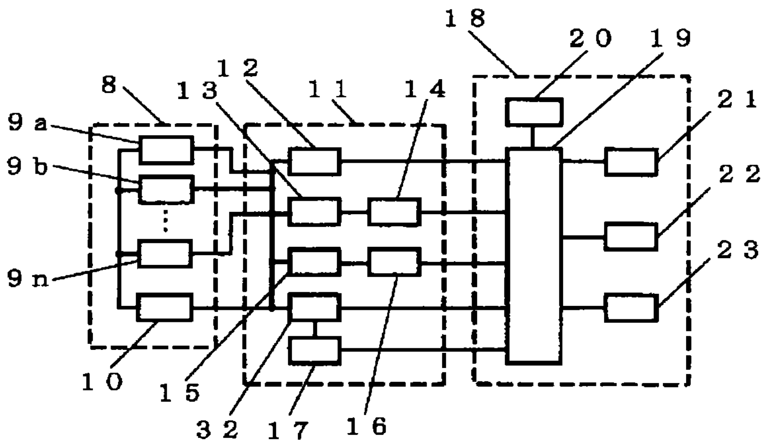
【図１６】



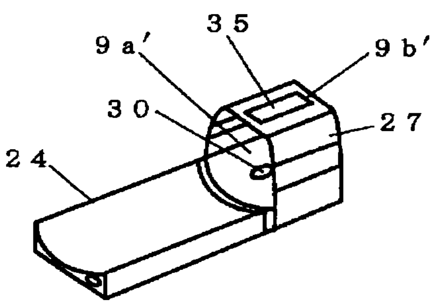
９ａ′　第１の脈波検出部
９ｂ′　第２の脈波検出部
３３　第２の発光部
３４　第２の受光部

【図１５】

９ａ～９ｎ 脈波検出部
３２ 脈波伝播特徴量演算部

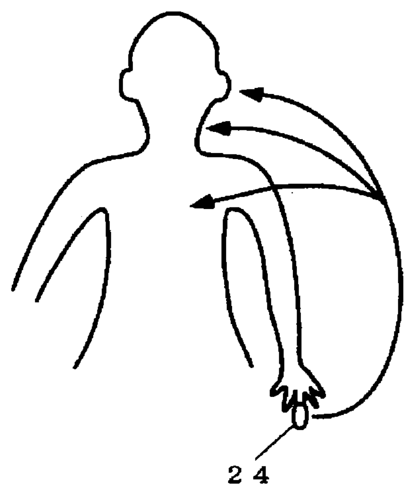


【図１７】

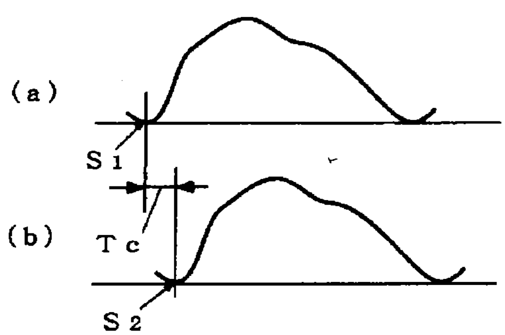


３５ 圧力センサ

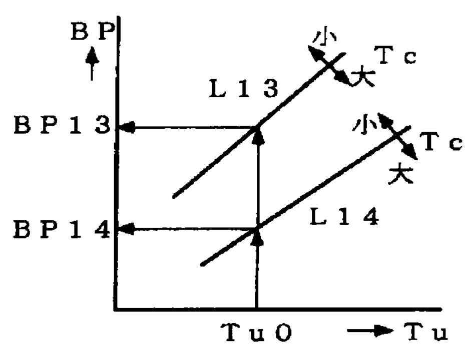
【図１８】



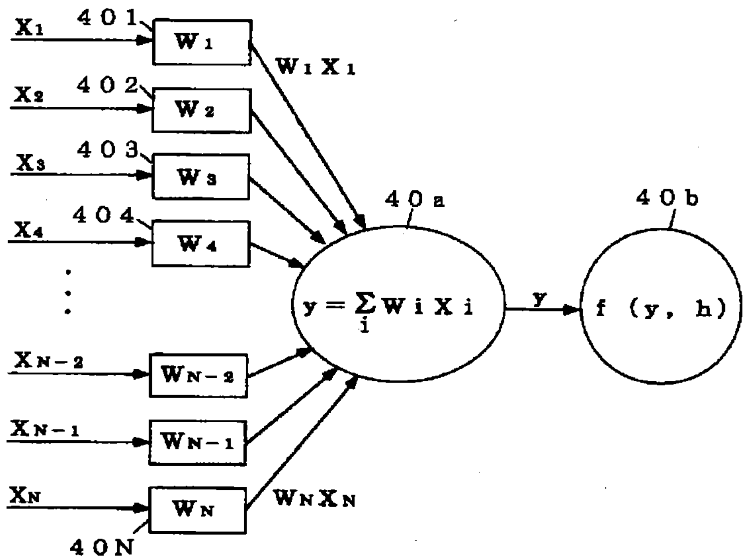
【図１９】



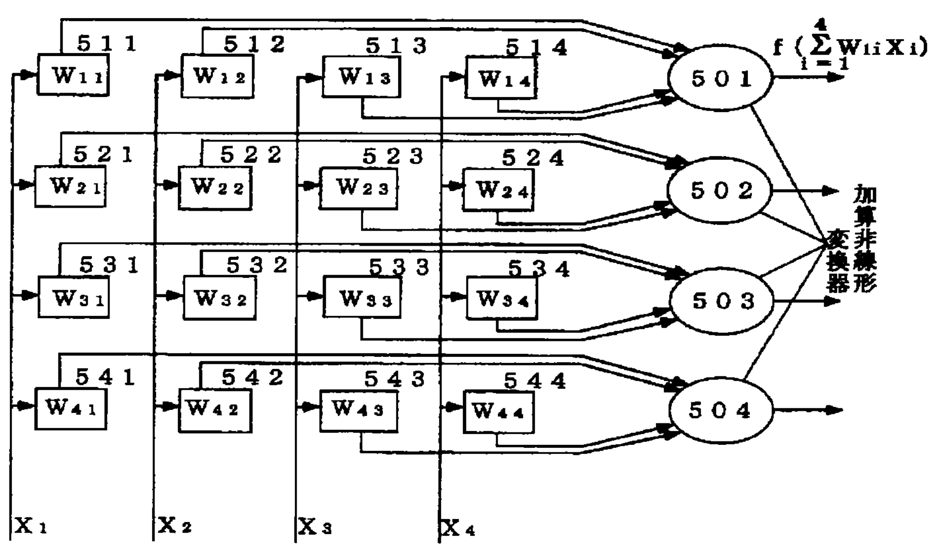
【図２０】



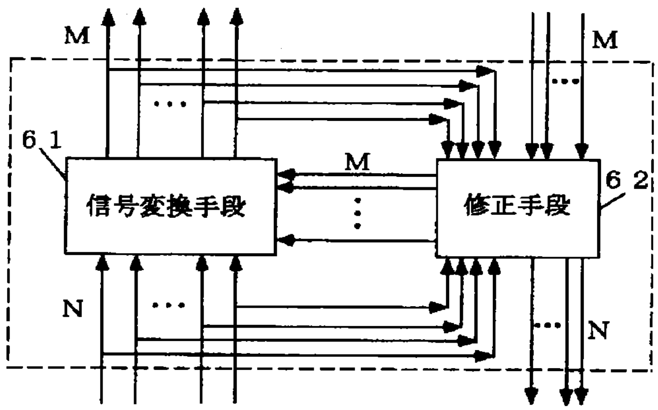
【図２１】


X1
401
W1
W1X1
X2
402
W2
X3
403
W3
X4
404
W4
40a
40b
y = Σ Wi Xi
i
y
f (y, h)
XN-2
WN-2
XN-1
WN-1
XN
WN
WNXN
40N

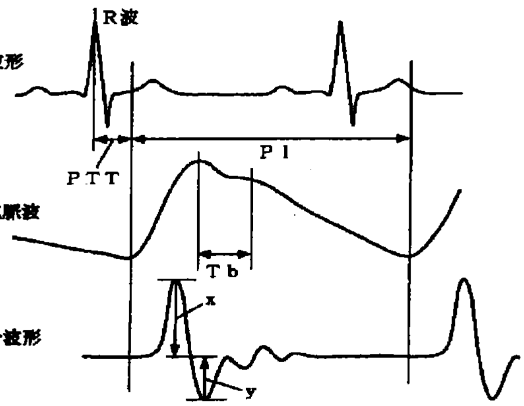
【図２２】


511
W11
512
W12
513
W13
514
W14
501
f (Σ W1iXi)
4
i = 1
521
W21
522
W22
523
W23
524
W24
502
加算非線形変換器
531
W31
532
W32
533
W33
534
W34
503
541
W41
542
W42
543
W43
544
W44
504
X1
X2
X3
X4

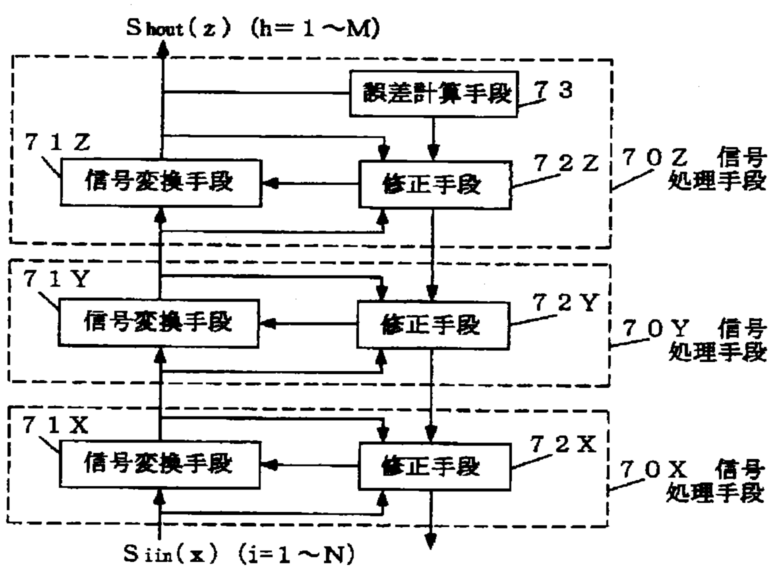
【図２３】


M
M
６１
信号変換手段
M
修正手段
６２
N
N

【図２６】


R波
心電位波形
PTT
P I
指尖光電脈波
T b
x
2次微分波形
y

【図２４】


S hout(z) (h=１〜M)
誤差計算手段
７３
７１Z
信号変換手段
修正手段
７２Z
７０Z 信号
処理手段
７１Y
信号変換手段
修正手段
７２Y
７０Y 信号
処理手段
７１X
信号変換手段
修正手段
７２X
７０X 信号
処理手段
S iin(x) (i=１〜N)

【図２５】